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The Journal of THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

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Journal of the Australian Institute of Agricultural Science

Vol. 24. No. 2. June, 1958

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Guide to Authors

The Journal aims to publish material of interest to Agricultural Scientists, contributed by authors working in agricultural or related fields; authors need not be members of the Institute.

Contributions are of three types, namely: "Articles", "Technical Papers" and "Technical Notes". For information about the size and form of each type of contribution, see page 2 of the March, 1955, issue of the Journal.

Manuscripts should be double spaced and should be submitted in duplicate, as part of the delay in referring is then avoided.

For more detailed information concerning the preparation and lay-out of scientific papers, authors are referred to the C.S.I.R.O. publication "Guide to Authors" and to an article entitled "The Preparation and Editing of Technical Papers" by N. S. Noble, published in the Australian Library Journal, April, 1954. The policy laid down in these publications is also largely followed by this Journal.

In addition to the contributions described above, the Journal is pleased to publish "Letters", "News Items", "Talks" and "Personal Notes" which have been received from, or which are of interest to, members of the Institute.

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Presidential Address

AGRICULTURAL RESEARCH AND FARMING

W. A. T. SUMMERVILLE

In delivering this, the Presidential Address for the year 1957-58 to the Australian Institute of Agricultural Science, I wish to speak more particularly to the younger members. My reason for this is that I want to look ahead a little and what lies ahead must lie largely in the hands of the younger members.

In the practice of agriculture, since biological material is being dealt with, attention is directed essentially to the ever-changing scene of growth, reproduction, death and decay, with that variability so characteristic of living matter constantly to the forefront.

In such an environment of development and change it is not always easy to realise that in the final analysis one of the great problems, indeed the greatest, is how to ensure permanence. Obviously if the needs of the world in food and clothing are to be met agriculture must continue indefinitely. Whilst it may be true that with the advance of chemistry in particular, materials previously available only through natural occurrence can be replaced by artificially synthesised substitutes, it is surely not reasonable to visualise total or even substantial replacement of the great bulk of Man's necessities by such substitutes.

To the agricultural scientist it may appear trite to refer to the soil, air and water as the basic raw materials for manufacture by plants, with the sun as a constant which is available virtually everywhere as a source of cheap energy; but those are the real facts from which we must reason.

These are the factors which determine that agriculture, i.e. plant and animal production, is not only the natural and logical method of providing so many of Man's necessities, but that by reason of the distribution, ease of availability and cost of these contributing factors agriculture will continue to be the source of supply of the bulk of those needs.

It becomes then an essential task of the agriculturist, be he producer or professional scientist, to ensure preservation of those resources on which the future existence as well as welfare of mankind depends.

Mere exploitative agriculture is thus something which cannot be contemplated.

Eliminating the factors over which Man has no measure of control insofar as totals are concerned, there remains the soil, and this is the only one there is any real danger of depleting within time which can be comprehended. Further, that danger is real. Fifty, a hundred, or even five hundred years, have little significance in the history of a race of people or the world, but exploitative agriculture has before now converted millions of acres of fertile lands to useless waste in less than such periods as these.

It has been calculated that when all the factors limiting agriculture, such as sunlight, rainfall, temperature, topography and fertility, are taken into account, somewhere about seven per cent. of the world's land is suitable for the practice of agriculture.

It is admittedly very difficult to prove the accuracy of that or any other figure but it is quite certain that seven per cent. is sufficiently correct to serve as a guide.

It is true that with the advancement of science, lands once useless for agriculture can be made to yield crops, but the total area which can be visualised as being so changed can have little significance in the world pattern or total production, important though it may be over restricted tracts.

Similarly, the extension of irrigation may compensate in some of the areas ruled out because of inadequacy or unreliability of rainfall, but the probable significance of this may be judged when it is considered that even in Asia with its great irrigation areas only 1.4 per cent. of the total land is artificially watered, whilst in the United States of America the percentage is 0.6.

Nor is there any immense area of presently potential agricultural land still undeveloped. In modern times attempts to bring in great new areas of land for intensive production have at least not met with spectacular success —rather the reverse.

All this must be considered against a background of world population increasing at the rate of almost 22 million a year, and the demand for improved standards of living in the most populous parts.

Such a consideration can bring only one answer—there can be no loss of agricultural potential if there is to be survival. This means in essence that the only alternative to catastrophe is permanence of the productivity of the soil.

At first sight it might appear that the role of many agricultural scientists does not give them any great part in attaining this goal, but a full analysis quickly shows that whilst the short term goal may be but very remotely concerned with the ultimate objective of permanence, nevertheless the great majority do in fact make a contribution.

The entomologist, for example, grappling with a plague of army worms in a restricted area will generally be concerned wholly with what the situation will be a day or a week hence and not with a year, a decade or a century. But every fact elucidated which adds to the advancement of knowledge of insect control is a step along the path to permanence, provided always that it is recorded and made use of in association with such other information as may be gathered relevant to appropriate crops.

Similar statements could be made with respect to most other branches of agricultural science, and in the final analysis the contribution of such men engaged in what might be termed ancillary services or on comparatively short term or circumscribed problems can and must add materially to the solution of the wider problem.

To pursue the thesis of the entomological aspect, it would not be much consolation to a hungry world to know that we can grow food but can't harvest it because of the depredations of an insect.

But the larger question must always be concerned with getting the crop from the soil in the first place, and the major responsibility for the future must lie with those who seek to utilise the soil potential. The idea of exploitation concurrently with conservation contains perhaps something of a paradox, but so too does the continued survival of any form of life since the cycle of living invariably includes a phase of death and decay.

The paradox is of course not a real one since except in essentially quite primitive conditions any removal of a constituent from the soil may be largely an irrevocable loss of that particular mass, but that only means that an equivalent amount of that matter must be brought in from elsewhere, or that the amount removed is so small a proportion of the whole that its loss is insignificant.

Insofar as chemical composition of the soil is concerned there we are confronted with a fairly straightforward proposition. It may be noted, however, that whilst the proposition is fairly straightforward it is not always by any means simple, and agronomists will undoubtedly be confronted with problems arising out of the use of soil amendments as long as crops are grown.

But chemical composition is only one aspect of soil fertility and with increasing frequency it is not the most important. It is in the physical structure of the soil that the key to fertility so frequently lies. And of greatest moment in the struggle towards permanence in agriculture is the fact that it is in the physical condition that the greatest deterioration of cultivated lands takes place.

It is to be understood that it is not soil erosion as such that is being discussed. Catastrophic as soil erosion may be in comparatively circumscribed areas, it is far from as important as fertility erosion when a world-wide view is taken. It should be at once added that the erosion of the soil, in common with the loss of fertility, is associated quite largely with loss of physical structure.

Soil scientists lay great stress on the fundamental importance of structure and are insistent on the virtues of having the soil particles aggregated into crumb formation. It does not require any profound knowledge of physics and chemistry to appreciate the reasoning behind this insistence. It is true that many plants, including crop plants like tobacco and pineapples, will thrive on single grain structured soil, but those who have any length of experience of such soils appreciate just how difficult it is to maintain their productivity over even as short a period as 30 years. At the opposite end of the scale the massive clays are problem soils from the time they are first worked, and it is only by so treating them that they tend towards the crumb that they can be rendered reasonably tractable.

Crumb formation is not yet fully understood but it is known that the process is basically mechanical and is essentially one in which particles are compressed together by plant roots and cemented and held in that state by organic and inorganic colloids. The roots too help to break as well as compact so that there is no massive structure produced. Whilst this complex phenomenon is not wholly understood a great deal has been elucidated, and most important of all it has been shown that by far the most efficient agent in the process is grass. Without putting in all the steps then, it is clear that in the present state of knowledge permanence of agriculture must be based on the judicious use of grass.

Of course in the great agricultural regions of the world the judicious use of grass means that, if for no reason other than sheer economics, the grass must be used to produce animals. In this connexion the pasturing of animals is of itself beneficial, though here again the full facts are not yet known. Apart from the obvious advantage of return of organic matter to the soil there is evidence that other effects, perhaps hormonic in nature, are produced. And it seems that, apart from the direct economic advantages to the producers, the marriage of crop production to animal production holds the real key to sustained production.

It cannot be argued that as yet the productive capacity of the world's soils is seriously menaced. In every enlightened country production per acre and per man is increasing, and in Australia for example it is obvious that the limit on production is set not by any purely agricultural factor but by economic returns. Unfortunate as it may seem, there is a point beyond which purely agricultural efficiency is not a paying proposition. This has at least the virtue in some cases of reducing exploitation.

But this is rather a digression in that it pertains only to the present and the immediate future. It is the really long term view which matters, and because at the moment or for the next fifty years we could increase the world's production of food and fibre, it does not follow that the outlook is bright. It can only be bright if it is known that that production is not being achieved at the expense of irreplacable materials or other aids, and that the increase can be made commensurate with the increased needs.

All this adds up quite simply and clearly to the conclusion that the real problems of agriculture are never simple but embrace the whole field of the plant and animal in the total environment. Further, no solution which does not permit of integration into the concept of preservation of soil resources is of greater significance than any palliative.

The Role of the Institute

Now, we may ask, what has this to do specifically with the Institute of Agricultural Science?

At our Annual General Meeting held in Sydney last year, when matters pertaining to the future of the Institute were being discussed, some fear was expressed that with the growth of specialist societies such as Soils Science and Agricultural Economics there was a possibility that the importance of the Institute of Agricultural Science might diminish and that we might not be able to command the support of many of our present constituent scientific disciplines.

This is something which I feel merits our very close attention both as members of the Institute and as scientists, and such examination against the background of the concept of permanent agriculture will I feel go a long way towards answering the question I have just posed.

Loyalty to the Institute, commendable though it may be, cannot be expected to achieve a great deal over any appreciable period unless it is accompanied by the possibility of the organisation providing its members with some form of service commensurate with cost and not otherwise so readily available.

I feel that the information we must seek cannot be deduced simply by reference to the avowed objects of the Institute as set out in the Articles of Association. The constitutional commitments can only serve as a guide to theoretical potential and I feel we need something further than that if we are to examine the question.

One might start off by defining what we mean by agricultural science, and more particularly by deciding what categories of scientist are included. To the best of my knowledge no officer of any institution in Australia or elsewhere in the English speaking world is listed under the title of Agricultural Scientist. I certainly have never heard of a Principal, Senior, Assistant, or any other officially styled Agricultural Scientist. Our faculties of Agricultural Science turn out graduates destined to become agronomists, plant breeders, entomologists, horticulturists, bio-chemists, and a lot of other things, but none finishes up as an Agricultural Scientist. I have looked through the List of Research Workers as published by the Commonwealth Agricultural Bureaux and have not been able to find one officer described as an Agricultural Scientist. The nearest approach is a group largely composed of men with pure science degrees and called officially Agricultural Officer. What, we might ask, is the significance of entomologists and plant pathologists, soil conservation officers and soil fertility workers being listed as distinct from agricultural officers? These titles appear in a number of cases, particularly in the Colonial Service, so presumably somebody thinks they are different.

The obvious answer is that agricultural science is a generic term and in order to describe any individual it is necessary to be specific. But before we place any particular species in the genus we must be sure that it conforms to the characteristics of that genus.

At the outset then we have I feel to recognise that the term "agricultural scientist" should be confined to those working essentially towards improving the conditions of the farmer.

The soil scientist for example is not *per se* an agricultural scientist any more than is a taxonomist in botany or entomology. True the work of each may be used in furthering agricultural knowledge but from the agricultural point of view until the information gathered on say soil formation or identification of plant or insect is correlated with some agricultural problem or event, such information is merely raw material of potential value only. Such unrelated data is in the same category as a chemical which has just been synthesised and which may or may not be found to have an agricultural value.

The farmer cannot put his problem into water-tight compartments—he must relate any question to the extremely complex task of running his whole farm. In a like degree the agricultural scientist has to take the whole farm into consideration. True, every problem

does not mean detailed consideration of every facet of farming. The control of an insect pest in an orchard may not require the entomologist to worry over irrigation techniques or cultivation practice. On the other hand, he may have to consider very carefully just those things, and at very least he must satisfy himself that insofar as the job he has in hand is concerned they have or have not consequence. Otherwise the entomologist can scarcely claim to be an agricultural scientist.

It is still true that no problem can be efficiently solved until it has been properly defined. I cannot visualise how any problem can be properly defined unless cognisance is taken of the environment. And when we talk of the environment we are thinking in terms of complexity of crop, soil, water, climate, pests, pathogens, farmer himself, and so on.

Even the economics might be regarded as part of the environment, but, whether you accept that proposition or not, no farmer's problem admits of ignoring economics, and we must think not only in terms of natural environmental factors but frequently of artificially introduced ones as well.

Of what use is the theoretical solution to a soil fertility problem which ignores harmful residual effects on the growth of following crops in a sound rotation? Of what value a wheat with fantastic yielding capacity if machinery cannot handle the harvest? One could go on and on, most examples being so simple perhaps as to look almost puerile when set down on paper. Such examples are however the extremes and as such are not likely to be of real moment in practice. But I would be much less confident in making any pronouncement as regards less glaring cases.

Many of you will have heard of the agrostologist who complained bitterly of the fool farmer who turned his stock in to trample over his beautiful pasture. Far fetched! But is it? I wish I could be sure it really was as impossible as it sounds. I can almost hear some agrostologist murmuring "electric fence". If he did then I admit he has mitigated the situation but he has done so by giving consideration to another important environmental factor—the grazing animal—which in the story as originally related was not in fact done.

To bring the problem near home, are you all quite satisfied that, in the problem you are now engaged upon, you are not working a little bit lopsidedly? Are the pathologists sure a fungicide is going to provide the real answer to the disease problem on which they are engaged? Are the soil technologists certain that a different crop rotation is not better than the soil amendment their analyses suggest? Is the plant breeder sure that the disease he is worrying about is the real cause of lowered yields in the district? And above all and over all are any of us satisfied that economics of our hoped for solutions are sound?

Specialisation is here to stay—it is inseparable from reasonable advancement. We must adopt it whether we like it or not—it is the only way for one scientist to take full advantage of the progress his predecessors have achieved. But anyone who is to fit into our definition of agricultural scientist must deplore the necessity for embracing it.

How then are we to overcome the weakness of this specialisation and at the same time exploit its virtues?

The complexity of so many of our problems is apt to be so bewildering that one can readily appreciate the reactions of the man who feels incompetent to handle the whole and makes a strategic withdrawal to concentrate on but a small fraction. Perhaps the wiser he is the more quickly and completely he restricts his field. But can he do this and still call himself or be considered by others as an agricultural scientist? Only, I would say, if he makes certain that his specialised approach is compatible with the broad agricultural one.

In any organisation administrative steps can be taken to ensure that several facets of any problem are examined and referred to appropriate specialists, but this can scarcely be considered an adequate substitute for any lack of agricultural appreciation on the part of the specialists on whom will fall the onus of finding a solution.

It is still necessary for the man actually performing the work always to keep the problem in perspective.

As I have said specialisation is indispensable. How then are we to combine specialisation with the comprehensive approach? It is here I feel that the Institute of Agricultural Science can play such a role that none of us who wishes to make really worthwhile contributions in the service of agriculture can do other than work for such a body. Not only can the Institute provide this service but if it is to survive it must do so.

Specialists societies can be, and to my own knowledge frequently are, of great value, and I do not wish to say anything which could be construed as being in any way derogatory or minimising their importance. But they are not a substitute for our Institute.

They may, and to a degree should, be more profound in their approach to their particular scientific discipline—but just as specialisation in the individual is called for, these other bodies must inevitably lose something in comprehensiveness through their efforts to delve more deeply. Put another way, they lose something of their agriculture in their pursuit of chemistry, entomology, or what other avowed purpose they are serving.

The Institute on the other hand cannot afford to devote too much of its time to fundamental approaches—it can only do so at a cost in the interest of those members not specialising in that particular branch.

In the proposition I have recalled being put forward at the Sydney meeting it seems to me the fear lay essentially in the fact that we are a hybrid collection, but surely this is our strength, and perhaps in the final analysis the only reason for the existence of such an Institute. The greater the degree of specialisation the greater the need for contact with the other branches—there is no other way in which we can with any surety be truly agricultural scientists. How better can we achieve these vitally necessary contacts? The Institute through its meetings and its publications cannot be expected to provide the full answer to this problem of overcoming the isolation which can so easily make a brilliant soils chemist into a poor agricultural scientist. But with even the most moderate quality leadership it can and inevitably would exert such influence that those who wish to serve agriculture will get stimulus and information such as to ensure that no form of intellectual isolation will bar their way.

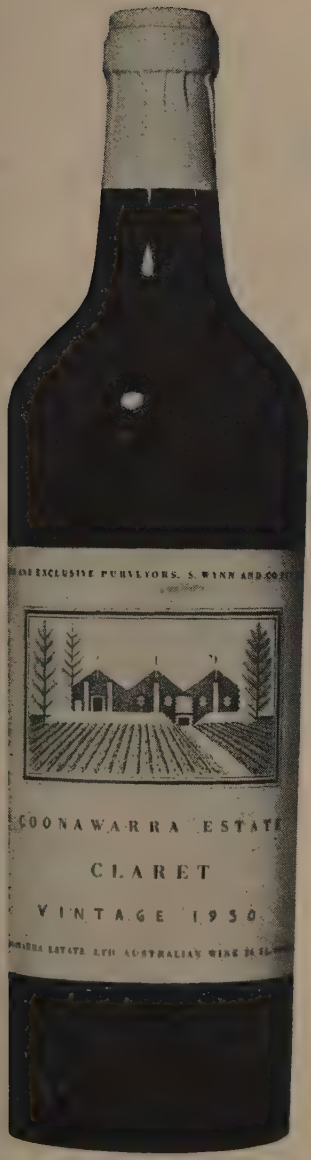
No society serving only a specialist group can be considered as a substitute.

Looked at from the theme on which I started out—that of permanence in agriculture —I can conceive of no alternative to this blending which the Institute alone can achieve. I said can achieve, not will. Whether its potential is exploited is in the hands of the indiyiduals, each individual. The extent to which that exploitation takes place is, I am convinced, to be viewed as a measure of our sincerity in our professed desire to help the farmers of the country.

Our constitution has been carefully written to ensure that standards will be maintained, and whilst our proceedings may seldom delight the single-minded disciple of the pure sciences, there should be no danger that empirical, shallow, or mere social approaches will ever loom large in our affairs.

In conclusion, then, I feel the Institute provides a most essential facility in ensuring that the specialist, without losing one whit of his allegiance to his speciality, can still qualify not only to be called an agricultural scientist but to be one.

Without such a facility I foresee an ever-widening gap between the research worker and the farmer—I can think of no more deplorable development in relation to our problem. Having in mind just what that problem is in relation to the future of the world I would suggest that the Institute of Agricultural Science, by dedicating itself towards the permanence of agriculture, would ensure an impregnable future for itself. What is more, it would deserve to survive and, if I may be forgiven for finishing on a philosophical note, the best humans can hope for in any field is to deserve success, and by and large we get what we deserve.



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DROUGHTS CAN BE BEATEN

M. C. FRANKLIN

One would not be justified in claiming that droughts will be prevented in Australia in the foreseeable future.

I am sure, however, that we can beat most droughts, and certainly reduce the devastating effects of even the most severe, if the best in practical and scientific knowledge is pooled and applied efficiently.

Adequate fodder conservation is the only certain preventive of drought losses. I do not mean just larger and better reserves of hay, silage or grain. Fodder conservation includes:

Reserves of hay, silage and grains.
Standing reserves of pasture grasses.
Fodder crops, and
Irrigated pastures and crops.

Unfortunately, none of these is adequate to satisfy present requirements, particularly in Queensland and New South Wales, two of the most vulnerable states.

Grain reserves have fallen below "safe" levels.

Hay and silage supplies are totally inadequate.

Fodder crops are not likely to make a substantial contribution.

Areas producing irrigated pastures and crops are only a small percentage of this country's potential.

Standing reserves of pasture are still satisfactory in most areas but continuing dry conditions could affect both quality and quantity over the next few months, or even weeks.

Were it not for this rather depressing background to present conditions I would have confined my address to long-term planning against droughts. I intend, however, to discuss the two questions:—

What advice can one give to counter existing adverse conditions?

How can long-term planning be improved?

MEETING PRESENT CONDITIONS

General Policy

There are at least four things a grazier can do as a drought worsens.

He may gamble on the drought breaking and take no action to guard against losses.

He may reduce his stock numbers by selling surplus stock.

He may seek agistment, or

He may hand feed.

Arguments can be advanced for or against each of these policies. Their soundness will depend on a number of factors, beyond the scope of my address this evening.

Let us consider, however, the case of the grazier who is in an area where the chances of getting effective rainfall are better than 50 per cent. There are many so located and they must be prepared to feed their stock until the drought breaks rather than adopt a "laissez faire" policy with the risk of heavy losses.

Let us assume that he

Cannot obtain satisfactory agistment.

M. C. FRANKLIN, M.Sc., Ph.D. (Cantab.), is William McIllwraith Fellow in Animal Husbandry at the McMaster Laboratories, Sydney. *This review is the text of his address to the Drought Symposium held by the Men of the Land and the N.S.W. branch of the A.I.A.S. in Sydney on October* 31, 1957.

Has sold some of his stock but does not wish to reduce his numbers further.
Is now prepared to start hand-feeding on fodder he has conserved and, if necessary
Is prepared to purchase additional fodder.

The questions he wants answering are:
When to start feeding?
What to feed?
How much to feed?
How to feed?

When to Start Feeding

It is important that sheep take readily to supplementary feeding. Otherwise, the problem of the "shy feeder" may create additional work and worry.

We have found lucerne hay one of the best supplements with which to start hand feeding.

I would not recommend over-generous supplementation too early in a drought unless substantial fodder reserves are available.

In our experience, sheep, in good condition, can lose approximately 40 per cent. of their bodyweight before heavy losses from undernutrition occur. Furthermore, survivors of such a regime of undernutrition will rapidly regain weight after a drought breaks, provided of course, food and conditions are satisfactory during the immediate post-drought period. Too often one hears of losses of drought-affected sheep "chasing a green pick" particularly in heavy, black soil country.

With this experience of the performance of sheep under nutritional stress, I agree with those who have been critical of some sections of our Press which have, during the last few months, over-publicised the problems of drought, fodder shortages and potential livestock losses. This does not mean that I have not agreed with the views expressed in many of these articles. My only criticism is that their timing has been bad. These articles have stampeded some into using fodder reserves before they needed to and have forced prices of fodders up too high too rapidly.

So much of this newspaper publicity of the last few months should have been made during the bounteous years, following the 1945-46 drought, and should have continually emphasised the need for greater fodder conservation.

What to Feed

From a nutritional viewpoint the choice may be as wide as the range of fodders available once stock have become accustomed to feeding. In our experiments we have fed roughage only, grains only and many combinations of these.

The cheapest and best drought fodder is that which provides the greatest number of

TABLE 1

Cost of Fodder, Cloncurry, Queensland—prices ex store 22/9/57.

Fodder	Cost	Cost per lb	Cost per food unit	Cost per pound of protein
		Pence	Pence	Pence
Grain sorghum	28/6 per bus. (60 lb)	5.7	7.6	57
Wheat			7.9	52
Maize			7.3	57
Poultry mash	12/- per bus. (20 lb)	7.2	11.0	51
Crushed oats	77/- per bag (100 lb)	9.2	15.4	92
Lucerne chaff	66/- per bag (100 lb)	7.9	19.8	53
Oaten chaff	67/3 per bag (100 lb)	8.1	20.2	146

food units at minimum cost, provided, of course, that it is reasonably palatable.

There is little excuse for careless buying of fodders when one has a choice from which to select. There are, however, many examples of bad buying of drought fodders by graziers. The following example, from North Queensland, came to my notice only a few weeks ago and is similar to many others one hears of from time to time.

Table 1 shows the cost of fodder at Cloncurry at the time. Obviously, the most expensive, and therefore least satisfactory fodder on economic grounds, was the oaten chaff. This had been purchased, however, by a local pastoralist as his choice of a supplement for cattle. His fodder costs could have been reduced to approximately one third, or alternatively three times as many food units could have been purchased for the same sum, if he had known the relative values of these fodders and purchased accordingly.

How Much to Feed

Research work by C.S.I.R.O. and the N.S.W. Department of Agriculture at Glenfield has established levels of feeding necessary for the survival of various classes of Merino sheep under drought conditions. Examples of this information included in Table 2 give the weekly requirements in feed units and, based on these, actual quantities of oats, wheat and hay.

Obviously standards such as these are valuable not only as a guide to daily or weekly fodder requirements but also for estimating total requirements for more extended periods. Their use enables one to consider supplementary or complete hand feeding objectively.

For example, what would be the effect of increasing fodder storage in Australia by the following amounts?

Wheat—100 *Million Bushels*

This would be equivalent to 4,320 million food units and would satisfy the full drought maintenance requirements of:—

252 million dry, adult Merino sheep for one month.

41.5 million dry, adult Merino sheep for six months.

20.8 million dry, adult Merino sheep for one year.

Hay—3 *Million Tons*

This would be equivalent to 2,352 million food units and would satisfy the full drought maintenance requirements of:—

137 million dry, adult Merino sheep for one month.

22.6 million dry, adult Merino sheep for six months.

11.3 million dry, adult Merino sheep for one year.

Considerations such as these make it possible to get our fodder conservation and storage plans in proper perspective.

TABLE 2

Feed requirements for drought maintenance of merino sheep.

Class of sheep	Food units per week	Oats per week (lb)	Wheat per week (lb)	Prime hay per week (lb)
Weaners	3	4.8	4.2	7.5
Adult dry sheep (live weight 75 lb)	4	6.4	5.5	10.0
Ewes six weeks before lambing	5	8.0	6.9	12.5
Ewes with lambs at feet	7	11.2	9.7	17.5

How to Feed

I do not propose to discuss such problems as types of troughing, trailing grain, chaffing roughage or feeding it in the long condition, grinding grain or feeding it whole. Advice on these will vary according to local conditions and is readily available.

The problem I wish to discuss under this heading is the frequency of feeding. Experiments on this have featured prominently for some years in our research programme. Feeding periods have varied from daily to once a week and have included periods of 6-12 months with mature dry sheep, in-lamb ewes and weaners.

Several thousand sheep have been fed in these experiments. Without exception, those fed at periodic intervals have done as well as, or better than, those fed daily. The results have been so consistent that we are convinced that daily feeding, on the low food intake commonly provided for survival during a drought, is unsound husbandry and should be abandoned in favour of feeding at longer intervals. The saving in labour is obvious.

The data in Tables 3 and 4, taken from one of our experiments in which 400 three-year-old Merino wethers were completely hand-fed for 49 weeks at daily and weekly intervals, illustrate the effects of the two systems of feeding.

TABLE 3

Effect of feeding interval on food consumption.

Ration	Daily groups Amount per day	Weekly groups Amount per week
	lb oz.	lb oz.
50% Wheaten chaff 50% Wheat	1 1	7 7
33⅓% Wheaten chaff 66⅔% Wheat	1 0	7 0
20% Wheaten chaff 80% Wheat	0 15	6 8
10% Wheaten chaff 90% Wheat	0 14.	6 2

Note: 1½ per cent. of ground limestone was added to all rations, which supplied 4¼ food units per sheep per week.

TABLE 4

Effect of feeding interval on sheep losses.

Period	Loss in daily-fed groups	Loss in weekly-fed groups
	Per cent.	Per cent.
0-100 days	9.4	1.4
0-200 days	16.6	3.5
0-300 days	28.1	9.7
0-343 days	30.2	11.8

TABLE 5

Comparison of costs and survival rates of daily and weekly feeding.

Group	Daily-fed		Weekly-fed	
	Costs	Per cent. surviving	Costs	Per cent. surviving
	£ s. d.		£ s. d.	
50% Chaff 50% Wheat	3 2 7	88	2 10 2	96
33⅓% Chaff 66⅔% Wheat	3 16 2	79	1 19 6	92
20% Chaff 80% Wheat	3 5 2	79	2 1 9	100
10% Chaff 90% Wheat	4 7 10	70	1 4 11	96

The differences in the losses favoured weekly feeding.

Costs also favoured periodic feeding. With wool at 96 pence per lb., sheep at £4 per head, chaff at £25 per ton and wheat at 16/- per bushel, costs of bringing the sheep through in each group, for the 49-week drought feeding period, are set out in Table 5.

Some Special Considerations

There are other important details which should receive attention.

Utilisation of Low-quality Roughage

Frequently, the quality of the dry, standing roughage is so poor that it will not hold sheep in satisfactory condition. Deficiencies of protein, minerals and carotene are the limiting factors and the results of our experiments indicate that the deficiency of protein is probably the most serious of these. For some years now C.S.I.R.O. and the N.S.W. Department of Agriculture have been studying the problem. The results of these experiments have demonstrated the value of protein-rich supplements for livestock forced to subsist on very low-quality roughage. The data in Table 6 are typical of the results we have obtained.

TABLE 6

Cost of feeding merino weaners on low-quality roughage; on basis of 1000 sheep per group.

	Roughage *ad lib.* (3.5% protein)		
	No. Supplement	Linseed meal 3.1 oz.	Lucerne chaff 6.1 oz.
Survivors after 24 weeks	375	975	950
Wool:			
Per head (lb)	2.44	3.75	3.12
Per group (lb)	915	3656	2964
Return[1]	£278	£1109	£899
Loss from deaths[2]	£2125	£85	£175
Fodder eaten:			
Roughage (tons)	58.2	89.5	73.3
Supplement (short tons)	—	16.3	31.2
Fodder costs:			
Roughage[3]	£582	£895	£733
Supplements[4]	—	£733	£278
Total	£582	£1628	£1011
Total costs (24 weeks)			
Fodder + deaths, less wool return	£2429	£604	£282
Net cost per head based on survivors	£6 9 6	12/5	5/11[5]

(1) at 72.8 per lb.

(2) at £3/8/0 per head.

(3) at £10 per ton.

(4) Linseed meal at £45 per ton (short); lucerne chaff at £10 per ton (long).

(5) 11/10 (lucerne chaff £20/ton); 17/8 (lucerne chaff £30/ton).

Urea as a Supplement

Another project which has yielded important results in our research experiments has been a study of the value of synthetic urea as a protein substitute.

Urea contains a high percentage of nitrogen —42 per cent. This can be converted into bacterial protein in the rumen and subsequently be used to supplement the protein in the food. Urea is cheap—costing less than one shilling per lb.

Its only drawback is its toxicity under some conditions. A number of research workers have experienced trouble of this sort when they have used it. One must be careful to:—
Avoid feeding excessive quantities.
Ensure uniform mixing with the ration.
Provide a suitable carbohydrate-rich supplement which is essential if the rumen bacteria are to utilise the urea efficiently.

In our experiments urea fed at levels of 3 g and 6 g per head per day, or given twice a week at this average daily level, has given very satisfactory results when sheep have been fed on low quality roughage, and more particularly at the higher level of supplementation. Results in Table 7 are typical.

The benefit from the urea supplement far outweighed the additional cost. Total urea costs per sheep for 12 and 22 weeks, added at the 6 g level per day were only 10 pence and 19 pence respectively.

Early Weaning of Lambs

Replacement of sheep at the end of a drought is always costly and generally difficult. This position is aggravated by the high mortality rate among young lambs born during these periods of nutritional stress. Too frequently, ewes with lambs at foot are fed inadequately for milk production and, if the drought continues, the majority of lambs die.

Experiments have been included in our series of drought feeding investigations to

TABLE 7

The value of urea as a supplement of low-quality roughage—wheaten straw chaff given ad lib.

Supplement[1] (Average per day)	% survivors at 12 weeks	% survivors at 22 weeks
Linseed meal, 3 oz.	94	58
Lucerne chaff, 6.6 oz.	94	44
Wheat, 3 oz.	44	Nil
Wheat, 3 oz. plus 3.2g urea.	67	22
Wheat, 3 oz. plus 6.4g urea.	58	45
Wheat, 4.5 oz.	56	33
Wheat, 4.5 oz. plus 3.2g urea	88	53
Wheat, 4.5 oz. plus 6.4g urea.	82	58
Oats, 3 oz.	78	Nil
Oats, 4.5 oz.	67	11
Oats, 4.5 oz. plus 3.2g urea.	78	39
Oats, 4.5 oz. plus 6.4g urea.	78	55
Control—no supplement.	19	Nil

[1]Supplements were given twice weekly.

study early weaning as a means of improving survival rate and reducing the cost of rearing lambs in a drought.

Groups of Merino lambs have been weaned at 4, 6, 8 and 12 weeks of age and fed *ad lib.* on 50: 50 mixtures of lucerne chaff and whole oats or wheat. After weaning, the dams, of course, have then been treated as dry sheep and fed on drought rations.

Weaning at four weeks of age was unsatisfactory, but the weaning at 6, 8 and 12 weeks of age was successful. Data in Table 8 summarise the results for experimental groups of lambs weaned at 6 weeks of age and fed *ad lib.* in a restricted area, on a 50: 50 mixture of lucerne chaff and oats.

TABLE 8

Summary of food consumption and growth of merino lambs weaned at six weeks.

Age (weeks)	Liveweight (lb)	Food consumption (lb)		
		Per day	Per 4 weeks	Total
6	17.5	0.4	15	—
10	19	1.0	30	15
14	25	1.3	39	45
18	31	1.4	41	84
22	38	1.6	—	125

The results of these early-weaning experiments have been so successful, both from the viewpoint of survival rates and fodder costs, that my colleague, Mr. P. K. Briggs, and I have advised many graziers during the last few months to adopt this practice. We have emphasized the following points.

Lambs weighing approximately 17 lb can be weaned successfully at six weeks of age.

Rations consisting of a 50: 50 mixture of lucerne chaff and whole grain are satisfactory as weaning diets.

Food consumption of lambs at this age and weight is low and the cost of *ad lib.* feeding are, therefore, relatively small.

The lambs should be confined in relatively small areas, or yards, and thereby forced to rely entirely on hand feeding during the early post-weaning stage. In this connection, it is relevant to mention that in recent field work by Mr. Briggs with large groups of lambs, weaned early and fed along the lines recommended here, the only disappointing results have been obtained when the lambs have been weaned into large paddocks.

We are convinced that early weaning is a practice that should be adopted more widely during droughts. Perhaps the strongest support for this recommendation has come from a well known Merino breeder in the western district of New South Wales. This year he weaned 1,300 lambs at approximately nine weeks of age and completely hand fed them for the following six weeks. Recently he informed Mr. Briggs that he has been so satisfied with their performance that he proposes to adopt this early weaning and hand feeding as a standard practice in normal seasons and breed from his ewes twice a year.

These are some of the results of our research work on drought feeding. Other important points, some obvious, but often neglected, such as the need to ensure that supplies of drinking water for stock are adequate, must not be overlooked in any drought mitigation programme.

Before passing on to consider briefly how long term planning for droughts can be improved, let me summarise the main points in a programme for drought mitigation under conditions as these are at present.

Ensure that water supplies are adequate for drinking requirements.

Wherever possible, conserve and use water for irrigation, and ration the high-quality feed so produced.

Ration improved pastures and extend their areas where practicable.

Plan the feeding programme as far ahead as possible.

Accustom sheep to hand feeding, but do not waste supplies of conserved fodder by feeding before necessary.

Consider drought feeding problems quantitatively.

Grade stock according to condition and ration accordingly.

Consider the value of sheep which are to be fed and ration accordingly.

Feed at periodic intervals instead of daily. (Except early-weaned lambs which should be fed *ad lib.* if feed supplies are adequate.)

Wean early, and completely hand feed lambs.

Discontinue hand feeding when it is practicable to do so.

Make use of low-quality roughage.

Ration high-quality supplements.

Ration protein-rich supplements.

Add urea to grain supplements especially if the quality of the roughage is poor, but use it carefully because of the dangers associated with overfeeding urea or faulty mixing.

If necessary, add limestone to grain supplements. This can be important for young growing stock and for pregnant ewes fed mainly on grain rations.

If necessary, drench with a vitamin A supplement. This should be necessary only under conditions of protracted periods of grazing on dry feed, and even then only with lambs and weaners.

Where practicable, consider the merits of completely hand feeding a portion of the flock in a restricted area and thereby distribute the remainder of the flock more thinly over the property.

If one must buy feed, make sure that the purchase is basically sound, if there is a choice of several fodders.

LONG-TERM PLANS FOR DROUGHT MITIGATION

Even a casual analysis of rainfall data and stock losses over the last fifty or sixty years indicates clearly that Australia has never implemented a sound drought mitigation policy.

The prolonged droughts of 1892-1902 halved the sheep population. It took thirty years to restore it to the 106 million of 1891 and a further 10 years to reach a new peak of 125 million in 1942. Then followed the disastrous droughts in the middle 'forties. New South Wales and Queensland were most seriously affected with decreases of 15.7 and 9.5 million sheep respectively, representing 24 and 38 per cent. of their flocks. It was nearly ten years before the sheep population in New South Wales was back to that of the early 'forties. Today the Australian sheep population is about 27 million greater than it was in 1942 and that of New South Wales, with a total of approximately 68 million, is nearly 12 million above the 1942 total.

Violent fluctuations have also been a feature of beef and veal production. In 1915 there was a record production of 429,900 tons; four years later it had fallen to 274,200 tons. In 1925 production reached a new record of 505,000 tons; six years later it was down to 344,100 tons. In 1938 another record was made with 596,800 tons; eight years later it had fallen to 406,600 tons. Old records again toppled with a production figure of 749,700 tons in 1956.

These violent changes have not all been associated with alternating droughts and bounteous seasons but these two factors have undoubtedly exerted a major influence and will continue to do so until our approach to the problems of drought mitigation, and harvesting the surpluses of good years, undergoes a radical change.

We should examine more frequently the balance sheet of the drought position and take appropriate steps to correct its weaknesses.

We know: Livestock numbers.

The quantity of fodder conserved annually.

Fodder requirements for maintenance, growth, milk production, and so on.

We also know: Fodder reserves are inadequate.

We are reasonably certain that: Droughts will occur again.

We do not know: When the next really bad drought will occur, and

Its potential intensity. We may, unfortunately, be heading into it now.

I have already stated that adequate fodder conservation is the only certain answer to these problems. Pasture improvement, correct fertiliser use, rabbit control and improved pasture management, can help but no one or all of these provide the answer to drought control. Their main contribution, and a very important one too, is their large contribution to the growth of the total livestock population. There is, of course, a huge potential for this expansion as more and more country comes under

pasture improvement. But the need for increased fodder conservation, as hay, silage, grain and standing fodder reserves, or the strategic movement or sale of livestock, becomes increasingly important with these changes. I have stated elsewhere that those who believe otherwise are living in a fool's paradise.

It is important to keep one's thinking straight when considering the magnitude of one's fodder reserves. Too few do this. Every grazier should be encouraged to convert both livestock and conserved fodder to single units. I have done this for several properties in the data included in Table 9.

The comparative data in Table 9 have reduced the fodder conservation to intelligible terms. Our research work has shown that four Food Units will maintain a dry adult Merino sheep in reasonable store condition for one week. On property "A," therefore, fodder reserves are adequate to satisfy full maintenance requirements for 53 weeks; on property "D," they are barely sufficient for one month.

It is interesting also to reduce wool production per sheep and sheep-maintenance requirements to similar simple terms and thereby get the sheep production units and fodder costs in proper perspective. These data are included in Table 10.

TABLE 10

The economics of drought feeding.

If Annual Wool Production per sheep is:	Daily Wool Production will be worth:
£4	2.63 pence
£3	1.97 ,,
£2	1.32 ,,
£1	0.66 ,,
10/-	0.33 ,,
5/-	0.16 ,,

Alternatively, look at this balance sheet from the angle of Australia's annual wool production of approximately 9 lb. per sheep. On this basis:

With wool at:	Value of wool production per sheep: Per day	Per week
90 pence per lb.	2.22 pence	15.5 pence
80 ,, ,, ,,	1.97 ,,	13.4 ,,
70 ,, ,, ,,	1.73 ,,	12.1 ,,
60 ,, ,, ,,	1.48 ,,	10.4 ,,
50 ,, ,, ,,	1.24 ,,	8.7 ,,
40 ,, ,, ,,	0.98 ,,	6.9 ,,

TABLE 9

Assessment of fodder reserves.

PROPERTY	LIVESTOCK			FODDER						FOOD UNITS IN STORED FODDER	
				Hay		Chaff		Oats			
	Sheep	Cattle	Sheep Units	Total	Food units	Total	Food units	Total	Food units	Total	Per Sheep Unit
				Tons	lb	Tons	lb	bus.	lb	lb	lb
A	1100	—	1100	—	—	20	17,902	9000	216,000	233,920	212
B	1800	30	2000	290	227,500	—	—	3000	72,000	299,500	150
C	7000	400	9500	1200	933,800	—	—	—	—	933,800	98
D	7000	140	7850	87	68,200	—	—	2000	48,000	116,200	15
E	1400	—	1400	300	235,200	—	—	—	—	235,200	168

10 lb. hay per sheep per week is a maintenance ration for a Merino sheep.

With hay at:	Cost of a week's ration:
£1 per ton	1.1 pence
£2 ,, ,,	2.1 ,,
£3 ,, ,,	3.2 ,,
£4 ,, ,,	4.3 ,,
£5 ,, ,,	5.4 ,,
£6 ,, ,,	6.4 ,,
£7 ,, ,,	7.5 ,,
£8 ,, ,,	8.6 ,,
£9 ,, ,,	9.6 ,,
£10 ,, ,,	10.7 ,,

With these figures before me, I maintain that in most localities the average Australian grazier cannot afford not to conserve fodder. At present sheep and wool prices, it must pay him to do this and to hand feed his sheep in times of nutritional stress.

In conclusion, we must accept that stock raising conditions in Australia are so variable that no one set of recommendations provides the complete answer to the problems of drought mitigation. The following recommendations summarise a few of the more important points each grazier should consider:

Study local rainfall data. This information will be a guide to the size of fodder reserves one should provide, how frequently drought conditions may be experienced, their possible intensity, and so on.

Give fodder conservation a high priority and reduce the conserved fodder balance sheet to units of fodder per head of livestock in order to determine if the programme is adequate.

Make full use of scientific information on drought mitigation. Australia leads the world in sheep research work and it is important that the vast fund of research information be applied as widely as possible, and finally,

Where appropriate apply the recommendations for drought mitigation under present conditions to long term planning also.

Received for publication March 3, 1958.

Book Review

PLANT DISEASES DUE TO BACTERIA (2nd EDITION, 1957)

By W. J. Dowson

Cambridge University Press 232 pages. Price 32/6 sterling

The second edition of Dr. Dowson's textbook follows the same format as the original edition, being divided into three sections—

1. General characteristics of Bacteria (Classification, nomenclature, principles and methods of investigation).
2. Laboratory methods of study (Physiology, Biochemistry, Staining, Preparation of Media), and
3. Bacterial Plant Pathogens (Symptoms, etiology, method of isolation).

In this recent edition, Dr. Dowson has made available a good deal of newer knowledge on the etiology of certain bacterial plant pathogens and has provided current information on the use of antibiotics in control. He has included mention of the use of phages in identification and has described the application of microchemical tests in biochemical and physiological studies. He has brought his lists of references up to date and has added a new chapter on the preservation of bacterial cultures. The number of maps showing world distribution of bacterial plant pathogens has been increased.

This revision will make even more valuable a book which has always been of great assistance and interest to all workers in the field of bacterial plant pathology.

H. FREEMAN

FORESTRY AS A FORM OF LAND USE IN THE SOUTH WEST OF W.A.

D. W. R. STEWART

The suggestion for an address on the subject of forestry and land use in the Southwest arose out of a discussion with some agricultural scientists following purchase by the Forests Department of a number of agricultural properties in the Blackwood Valley near Nannup (Figure 1) for afforestation with coniferous species. Since forestry is usually associated with extensive rather than intensive land use, considerable surprise was expressed that such a form of land use could compete with agriculture and that the Department could purchase developed agricultural properties in the open market.

Forestry—A Form of Agriculture

Forestry is often described as a form of agriculture in which the crop rotation is measured in many decades rather than years. The period from seedling to harvest may vary from as little as seven years in eucalypt coppice forests in South Africa to as long as four hundred years in oak forests at Spessart in Germany. Rotations of one hundred to two hundred years are common. Our local West Australian hardwood forests will probably be worked on a rotation of about one hundred to one hundred and twenty years.

Intensity of Use

Like agriculture, this form of land use may vary greatly in intensity. If the number of families per unit area are considered as an indication of intensity of land use, we find that under agriculture in the Southwest, holdings may vary from as small as 20 to 30 acres for fruit growing, tobacco culture, or potato growing; to 500 acres for dairying; 1000 acres for extensive grazing; and up to 2000 acres or more for wheat and sheep. Dairying properties in the Southwest are stated by Kerr (1955) to average some 488 acres.

Our native hardwood forests, although far from developed to their highest potential, support directly in growing, harvesting and milling the crop, an average of one wage earner to 620 acres—not greatly different from dairying,—ranging from 250 to 300 acres per family in the more heavily timbered karri (*Eucalyptus diversicolor*) region to 1000 acres or so in the lower quality jarrah (*E. marginata*) forest. The figure of one family unit to 620 acres is exclusive of pile and pole getters, post cutters, beekeepers, tannin extract workers, plywood mill employees, etc. who also draw their livelihood from the forest.

Afforestation with fast growing conifers is, however, quite an intensive form of land use and more closely comparable with horticulture. In terms of wood volume production per unit area per annum, the yields are from ten to twenty times that of jarrah. Already young plantations from twenty to thirty years old are supporting one family per 100 acres or better and by the time they reach maturity at forty years, they will support one family per

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30 acres. South Australia, which has the greatest area of softwood plantation in the Commonwealth, estimates that within the next decade her 100,000 acres of artificial pine plantation will support one family per 25 acres, when the rotation age of forty years is reached by the oldest stands, and the annual cut is equivalent to the annual increment.

As the locations acquired in the Nannup area for pine afforestation were primarily dairying holdings, the comparison here is one between the economics of dairying and that of growing softwood on the same land. Some areas of hardwood forest have also been acquired, linking pine areas with existing jarrah forest to facilitate administration and protection. The dairying picture has been well covered (Schapper 1953), so it is proposed to concentrate here on the forestry aspect of land use.

Before discussing the economics of pine planting, it is desirable to outline the history of land settlement in the Southwest and the development of a forest policy, as a background to an understanding of the present forest policy with particular reference to softwood afforestation.

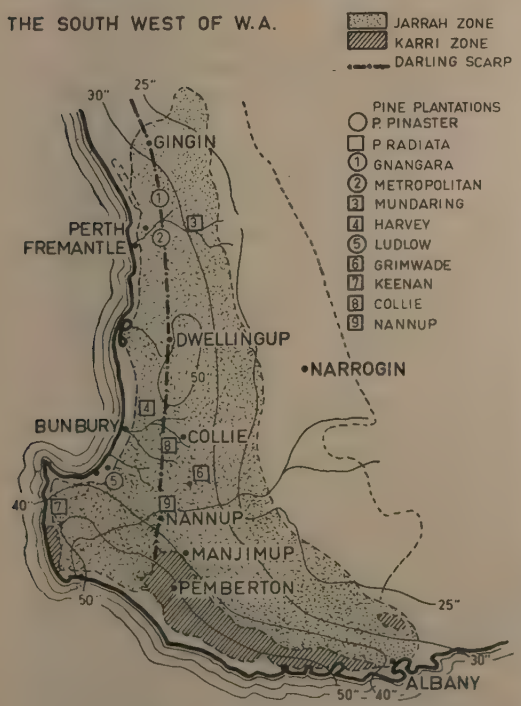

Figure 1.—Plantations and natural forest areas in the south-west of Western Australia.

History of Land Settlement

Of its 624 million acres, Western Australia contains only about 16 million acres within the zone of rainfall suitable for the permanent management of exploitable forest. This area also contains nearly all our most valuable catchment areas for potable water (Harris 1957).

Up till the end of World War I, it could be said that land settlement was quite unplanned. In the nineteenth century land grants were often made on plans with little knowledge of the areas. A surveyor-cum-explorer located suitable areas. Little or no value was placed on timber at that time and generally only the poverty of the soil saved the jarrah forest from virtual decimation. In the early decades of the twentieth century Crown grants gave settlers the rights to timber but this was not valued, and was frequently destroyed by ring-barking and clearing. Since 1931, all timber on land subsequently alienated is reserved to the Crown.

Agricultural settlement spread generally from the coast and up the main watercourses with selection of the better soils such as alluvials, and those of basic origin; in valleys like the Collie, Preston, Capel and Blackwood Rivers, and Balingup Brook. Watercourses, particularly if containing permanent potable water, were always an attraction for the early selections. Considerable settlement followed the development of the timber industry and as it expanded, many properties were taken up by timber workers who developed their holdings part time while drawing their livelihood from the timber industry. In traversing the South-west over the last thirty years, it has been most noticeable how effective were the early settlers in occupying the best of the soils. Doubtless much of the early selection was a matter of hit and miss, but experience soon found the lack of production from the poorer lateritic soils and many such areas were abandoned after selection, and often reverted to the Crown.

After 1920 came the era of planning land settlement, or rather of "misguided planning",

with the object of establishing a dairying industry in the prime forest country and settling migrant Britons on the land (Harris 1957). The scheme was political rather than economic. The choice lands of earlier selections were used as criteria of results to be expected from the remainder of the forest country, regardless of the fact that the soils of jarrah and karri forest generally were much inferior in quality.

This story has been well covered by Schapper (1953) and I will not dwell on it except to draw attention to one or two remarks in his comprehensive survey. He points out that the soils are inherently infertile and low in organic matter, deficient in phosphorus and often in copper, zinc, cobalt and manganese. Nitrogen was high by Australian standards and low by world standards. The suitability of such soils for dairying was not obvious. The soils were poor, pasture growth occurred for only six and a half to eight months of the year; land clearing costs were heavy; subsequent falling timber added to costs and carrying capacity was only four to five acres per cow. Furthermore, annual top dressing meant an additional cost of seven and a half cwt of super per cow and conservation of fodder was necessary.

By 1936 it had cost £9 million to establish 1,700 men on farms of low productive value, (£5,300 per man). The equivalent in today's money would be approximately £27 million. In addition, there had been a very substantial loss of a natural asset in the ringbarking and clearing of timber much of which was in virgin forest of prime quality.

The third phase, that of planned land use, is of very recent origin. For postwar planning, a small Land Utilisation Committee was formed in 1945, but it rarely met. In 1954 a new Land Utilisation Committee was constituted with broad representation from the main Government departments concerned, and comprised of knowledgeable men at the top of their respective professions. The Committee comprised the Surveyor General as Chairman, the Director of Agriculture, Conservator of Forests, the Soil Conservation Commissioner, the Hydraulic Engineer, and representatives of the Treasury and Public Works Department. This body, aided in its deliberations by the latest maps, air photos and results of detailed field assessments and soil surveys, has met at fairly frequent intervals.

As a result of its decisions, considerable areas were added to State forest, others were allotted for agriculture, and others again temporarily reserved until marketable timber was removed or until more detailed information was obtained to permit a sound decision as to their future use.

As a result of the recent additions, the forest estate of the Crown now stands at some four million acres and may yet be further increased.

Its value as stated by the Minister for Forests in 1954, i.e. after the Royal Commission of 1953 and quoted by Kerr (1955) was estimated at about £1,000 million. He added that it was the means of saving Western Australia some £11 million annually by using homegrown timber, as against what we would have to pay to import our requirements.

Policy

Until the passing of the Forests Act in 1918, the State had no forest policy and no permanent forest. The best of the agricultural land in the Southwest was already alienated together with much first class forest including a very big percentage of the Blackwood Valley from Boyup Brook to Nannup. The efforts to have prime forest dedicated were deferred and frustrated by the Government policy of the day, of forcing an artificial development of forest land for dairying, and there was very little dedication to forest until 1928, by which time most of the "Group Settlement" areas had been demarcated in forest country. Valid comparisons of hypothetical returns from the soil under forestry and agriculture were impossible, as the requisite data just did not exist. Such financial forecasts as were made, proved to be very wide of the mark.

From the inception of the Forests Department, the primary object of forest policy was to secure dedication of the minimum area of forest necessary to safeguard the State's needs for timber and forest produce in the future. Estimates of requirements ranged from three

TABLE 1

W.A. Forests statistics—sawlog volumes only—round figures.

A. TODAY.	
Production (Annual)	
State Forests	38,000,000 cu. ft.
Private Forests	12,000,000 „ „
Total	50,000,000 „ „
Export	10,000,000 „ „
Consumption	40,000,000 „ „
Population 650,000	= 60 cu. ft. per capita.
Sustained Yield (State Forests)	40,000,000 cu. ft.
B. THE FUTURE.	
Estimated population 1980	1,000,000 cu. ft.
Estimated consumption	60,000,000 „ „
Estimated production—	
State Forests	40,000,000 „ „
Private Forests	1,000,000 „ „
Exports	Nil.
Deficit	19,000,000 „ „
At 48 cu. ft./capita—48-41m Deficit	7,000,000 „ „
Present Pine Planting (Two species)	2,000 ac/an.
Estimated yield	20,000,000 cu. ft.
Present yield	1,000,000 „ „

to four million acres of the best of the remaining jarrah and karri, based on a grid assessment of the timbered areas of the South West.

Here it is pertinent to quote from a very comprehensive document published by F.A.O. (Francois 1950)—

> After the minimum forest area necessary to protect soil, water and climatic conditions has been secured, the forest policy should next endeavour to meet the wood requirements of the country as far as possible.

Also—

> Food requirements have of course high priority . . . but it is only too well known that nature is ruthless when cultivation extends to unsuitable areas; . . . present standards of civilisation cannot be maintained without a sufficient supply of wood. Collaboration with those responsible for agricultural policy is therefore essential.

There was a constant struggle over three decades to limit the spoliation of prime forest land and only since 1954 do we see that "collaboration" which is so essential.

Future Policy

Table 1 illustrates the pattern of the forest potential, the State's timber consumption, and its future estimated requirements.

Up to 1913, a year of peak production, most of our timber was exported. By 1928 we were using half our production. After World War II with increased population and a greatly augmented demand, less than 20 per cent. of production was available for export and most of this went to sister states, particularly South Australia which is deficient in hardwood timbers.

The production of the State today is at about the maximum the native forest can support in saw timber if sustained yield is to be maintained. It is obvious that with our population steadily increasing, within two or three decades our consumption will overtake our productive capacity. As the hardwood yield cannot be increased appreciably (although doubtless there will be a slow improvement over a very long term with better utilisation), our alternatives are either to import timber or grow more, and hence the policy of ensuring supplies by the growth of limited areas of fast growing softwoods. Furthermore, Western Australia has no commercial softwoods and pine can replace jarrah for numerous uses, thus enabling us to maintain a small but profitable export of a higher priced, high quality article in select jarrah and karri.

Western Australia also has some moral obligation to supply much of the hardwood requirements of South Australia and the Commonwealth Government which are deficient in native hardwood resources. Timber is about the only primary product which Australia as a whole must still import in large quantities to meet her needs. Western Australia is one State with the capacity to supply its own needs.

The hardwood forests of Western Australia therefore support an industry which stands on its own feet, without subsidy, gives almost as great a population density as dairying, contributes most of the railway revenue for lines in the Southwest and contributes to a high proportion of the port traffic of Bunbury and Busselton.

The existing timber crop is a going concern, a perpetual crop, and requires no immense outlay of capital such as would be required for conversion of the soil to other forms of use.

Minor forest produce is also of considerable importance in the forest economy, e.g.

1. The beekeepers quote a figure of six shillings per acre per annum as value of honey from the forest.
2. The export value last year of tannin extract was £588,000. In good wandoo forest, the industry may obtain from wandoo logs, extracts to a value exceeding £200 per acre.
3. The plywood industry directly employs about 270 men. Although based on karri during and after the war, the industry now imports a large proportion of its requirements. It also uses local pine to the supply capacity of our young plantations. As these plantations mature and can supply larger logs, locally grown pine will probably replace most of the imported peeler logs.

Future Industry

There is still a vast reservoir of raw material which can form the basis of substantial industries other than sawmilling, such as pulp, paper, and charcoal iron, without encroaching on the existing reserves of saw timber which today constitute the main output of the forest.

There is no place in Australia more favourably situated to supply raw material at low cost for a large pulp industry than the Pemberton-Manjimup district. Increasing population will undoubtedly see the establishment of this industry within the next decade or so, based on marri (*E. calophylla*), a little used timber today, as well as thinnings from karri regrowth.

There are also vast supplies of wastewood suitable for production of high grade charcoal to support a major iron smelting industry in the Southwest, many times greater than that of the Wundowie plant, where high quality pig-irons are produced which are in strong demand for special purposes.

Afforestation

The economies of afforestation are entirely different from those of the native hardwood forest.

1. Western Australia lacks softwood and there is a large and increasing demand for it. The State has a ratio of use of one softwood to nine hardwood, compared with

world figures of four softwood to one hardwood.

2. Imports are costly. It is much cheaper to grow our own and build up our own State economy—e.g. undressed 'Merchantable quality' oregon is landed at Fremantle for 160/- per 100 su. ft. F.O.B.—Local pine is supplied on rails to merchants at Perth for 80/- to 90/- per 100 su. ft.

3. Softwoods can replace hardwoods for many purposes, thus permitting the conservation of hardwood and retention of a small and valuable export trade.

Species

In selecting suitable species, our mediterrannean climate with its long dry summer severely restricts our choice. Of the limited range of potentially suitable species, practical trials over thirty years have shown conclusively that only two are really worthwhile on any large scale from the commercial angle, i.e.

1. *Pinus radiata,*—Monterey pine—indigenous to a restricted area on the Monterey Peninsular on the coast of California, and

2. *Pinus pinaster*—'cluster pine' or 'Maritime pine'—from southern Europe around the Mediterranean and Atlantic coasts. A Portugese strain, i.e. from the Atlantic coast, has proved far superior to other strains for local use. Seed provenance is most important.

The reasons for the choice of these two species are:—

1. On better quality soils of dioritic origin from the basic dykes which occur on limited areas in the Darling Ranges no other species remotely approaches the extremely fast growth rate of *P. radiata.*

2. On the poor coastal sands North and South of Perth where proximity to market makes pine growing attractive, no species can compete with *P. pinaster* in production of wood on soils of such low fertility.

With timber a bulky product, it is essential to grow it as close as possible to market.

The wholesale price of timber in an Australian capital is determined by components more or less of the following order as quoted by Jacobs (1957).

1.	Average price to grower	10%
2.	Felling and hauling of logs	20%
3.	Sawmilling charge	26%
4.	Freight of sawn wood	36%
5.	Commissions	8%
		100%

Therefore 1, the return to the grower, can be greatly enhanced by reductions of 2 and 4. Conversely, timber-growing can result in financial loss if the product is grown too far from market and freight is unduly high.

The ideal would be the growth of *P. radiata* close to the Metropolitan area but this is impossible on account of lack of suitable soils. The one exception is the Mundaring catchment area which has limited patches of basic soil on which the growth of *P. radiata* is a very profitable venture.

However, in most of the Southwest on soils from laterites and granites, plantations of *P. radiata* appear doomed to failure, unless current and future research open up new possibilities for its successful growth.

Therefore we must seek further afield for suitable soils of which there are extremely limited areas within State Forest. Hence the attraction of diorite soils in the Blackwood Valley on what was formerly prime forest country, alienated and partially developed for agriculture. Although this is some hundred and fifty miles distance from the main market, the growth rates of *P. radiata* are so remarkable that the anticipated financial results are more attractive than they are with *P. pinaster* grown within thirty miles of the metropolitan area.

With *P. pinaster,* it has been shown over the last two decades that with proper strain, introduction of a root mycorrhiza, some soil selection, and suitable manurial treatment, profitable stands can be grown on the very infertile sands both North and South of Perth. Although the volume growth potential is only about one third that of *P. radiata,* its proximity to market makes it a venture well worthwhile.

Production and Returns

M.A.I. is a term very commonly used by foresters to denote the "mean annual increment" or the average annual production per unit area, of woody material. It may refer to the total woody growth including branch wood; it may include or exclude bark volumes; or may refer only to the marketable bole of a tree (excluding the stump and the crown) down to a minimum specified crown diameter. In Australian hardwood it commonly refers to the volume of the marketable log under bark. In pine plantations we commonly use M.A.I. figure to cover all bole material, i.e. bark and wood down to a four inch top diameter. The M.A.I. for any species may vary tremendously with the quality of the site, and the stocking, and age, of the stands.

To give some perspective in considering the relative production of hardwood and softwood areas, figures of the following order are suggested as M.A.I. for reasonably well stocked stands on sites of fair average quality—

Jarrah	15-25	cu. ft.	/acre/annum		
Karri	75-100	,,	,,	,,	,,
P. pinaster	100-150	,,	,,	,,	,,
P. radiata	300-400	,,	,,	,,	,,

In terms of dry matter per acre this would probably range from three to four tons or more from *P. radiata*.

Quite apart from the quantity production, there is also the question of quality. The monetary return per unit volume may vary tremendously from quite a low figure for small diameter knotty or crooked logs to an extremely high figure for straight clear logs of plywood quality near to market.

Repurchased Farmlands

With this background, let us now consider the repurchased farmlands of the Blackwood Valley. The great majority of these properties are wholly or partially on good quality diorite soils which under analysis, show a fairly high phosphorus content. Experience has shown that, for *P. radiata,* the phosphate content is a very good indicator of soil suitability. Soils with a content of less than 0.011 per cent phosphorus are regarded with suspicion. Only soils showing better analysis than this are acceptable on present knowledge. It is noteworthy that practically no areas are suitable from among the "Group Settlement" properties which were subdivided since 1925, but all the purchases are of land which was selected at a much earlier date.

Many properties have become available for purchase at a figure as low as £4 per acre even when the greater part has been cleared, and rising to a maximum price of about £13 per acre. Furthermore, they had been on the market for some time before purchase. With such low figures for good quality soils, the value for the much poorer group settlement properties should be even lower. Schapper (1953) indicates that the average holding is valued at £7,365 in 1952, i.e. about £15 per acre. Apparently the Nannup properties must be well below average, or actual market values are today much lower than they were in 1952.

Factors which seem to have made it difficult for these old properties to be worked economically are—

1. Steepness of land and, in some cases, the nature of land with patches of rocky outcrops, both of which tend to preclude its effective working by mechanical implements.
2. The presence of bracken in quantity over much of the area.
3. Severe infestation by rabbits.
4. The outlook of the owners, some of whom were essentially extensive graziers in outlook with no inclination towards intensive and scientific farming.
5. Lack of capital for intensive development.
6. In some cases, the desire of farmers' wives to get to a centre with better amenities.

The Financial Aspect

In comparing the value of this land for forestry and agriculture, it is not proposed to submit the results of complicated calculations based on hypothetical figures to show the "expectation value" of the soil under pine for various rotations and treatments. Unknown factors such as long-term future markets and market values are too uncertain, and assumptions could be made to justify almost any contention. It is proposed instead to give some actual figures of results now being obtained in comparable

plantations at Grimwade some 28 miles north-east of Nannup and to indicate the probable trend of future markets and demands.

Between 1933 and 1942, some 900 acres were planted at Grimwade, originating as a measure for unemployment relief work. Far less was then known of soil suitability so that results vary from first quality stands on good soils of dioritic origin to near failure on lateritic soils. On some of the latter, some startling responses have been obtained by the application of zinc, which stimulates recovery, producing a useful stand, although much inferior to that on suitable soils.

The cost of establishment, i.e. clearing, planting, etc. was approximately £10 per acre (that would be about £30 per acre on today's values). Annual maintenance was approximately ten shillings per acre.

A first pruning at about twelve years cost approximately £2 per acre.

First thinnings which it is desirable to commence at about twelve years, were delayed until 1950 when a small sawmill was erected and thinning commenced in seventeen year old stands. They have continued steadily since that date.

Accumulated costs per acre up to seventeen years were therefore—

£10 + compound interest at say 4%—approx.	£20	0	0
Maintenance 17 years @ 10/- per annum + interest .. say	£12	0	0
Pruning £2 + interest for 5 years .... say	£2	10	0
	£34	10	0 ac.

The initial yield from thinning throughout the stands of acceptable quality was approximately 30 loads per acre, (i.e. 1,500 cu. ft.—1 load = 50 cu. ft.).

After deducting from the selling price of the sawn product on rail Perth, all costs of felling, hauling, milling, freight to Perth, overheads and administrative expenses, the net profit was £3 per load or £90 per acre, i.e. within seventeen years the net return was sufficient to repay all establishment and maintenance costs to that date, plus accumulated interest and still show a net profit of £55/10/0 per acre. Considered on this basis, subsequent thinnings, and the final crop would then be free of debt, and all future net returns would be profit.

The postwar inflation had, of course, made possible this extraordinary financial result, but even using the current figure for cost of establishment of about £25 per acre, the debt would still be extinguished by the returns from the first thinning.

It should be pointed out however, that this is largely made possible by the Department milling the raw material so that the residual £3 per load (or £90 per acre) represents both stumpage (or royalty) and sawmiller's profit. If the logs were sold to a private sawmiller, the result would be less attractive, in that the Department would receive only the sale value of the logs which might be as low as £1 or thirty shillings per load instead of the £3 net. The actual value of the sawn product on rails Perth from one acre in first thinnings would be approximately £264.

Normally in a healthy stand of *P. radiata,* thinning would be commenced at about twelve years and continued at five year intervals provided markets were available for the thinnings.

Growth rates are such that it is estimated that at least 15 loads per acre could be removed over five years. As trees increase in age and size there is also a quality increment with a corresponding increase in price per unit volume in the later thinnings, when bigger dimension material, clear knot-free material, and high quality plywood logs, are obtainable. However, even if there was no price increment, a regular net return of £45 per acre every five years, less £5 per acre for maintenance charges, would be obtainable, i.e. £8 per acre per annum.

Considering volume production alone, the maximum returns would probably result from a rotation of thirty to thirty five years. However, because of the considerable price and quality increment for bigger dimension material, it is fairly certain that the rotation

for *P. radiata* will be not less than forty years. Therefore after the first thinning, it could normally be expected that there would be four further thinnings, returning at least £160 net per acre over the ensuing twenty years, (i.e. £8 per acre per year). The final crop to be harvested at forty years would return at least 165 loads per acre with a high proportion of high quality logs, including a large number suitable for plywood production for which the net value could well be £4 to £5 per load, i.e. £660 to £825, or say £700 per acre every forty years, or £17 to £20 per acre per annum exclusive of revenue from thinnings.

Taking the more conservative figure of £4 per load, the final crop gives a net return of £600 per acre. The corresponding value of the sawn produce of the final crop would be close to £2,000 per acre.

Figure 2 gives a rough indication of what can be expected from one acre in forty years, first with an M.A.I. of six loads per acre and secondly with an M.A.I. of eight loads per acre. It is assumed that if this is thinned progressively, 75 loads per acre would be removed as marketable thinnings and 165 loads as final crop if the M.A.I. is six loads per acre.

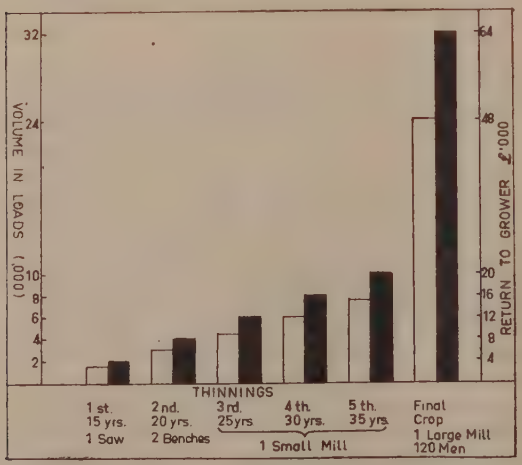

FIGURE 2—BLACKWOOD VALLEY PINE PLANTATION.

Estimated annual returns assuming planting rate of 100 acres per year and rotation of 40 years. Total Area 4,000 acres.

Assuming (a) White squares—M.A.I. 6 loads with thinning every 5 years at 15 loads per acre.
(b) Black squares—M.A.I. 8 loads with thinning every 5 years at 20 loads per acre.
(c) Royalty at £2 per load (11d. = 50 cu. ft.).

Pitfalls and Possibilities

The immediate reaction is "Where is the catch? These results look altogether too good to be true". Well there are of course many uncertainties. Demand will fluctuate; 'first thinnings' may not always be marketable which means early thinnings may be done without any financial recompense, or thinnings may be deferred until market conditions improve. There may be losses from fire, insects or disease.

As plantations increase in age with an abundance of larger diameter material available, it is possible that some of the smaller diameter material, i.e. from say eight inch down to four inch may no longer be saleable for saw logs. Today, with the whole output from thinnings, most of current production is within this four inch to eight inch top diameter range. This is where a pulp industry becomes of such vital importance, and can be of inestimable value in using a raw material, the removal of which enhances the value of the remaining stand. As mentioned earlier, it is expected that within the next decade or so, a pulp industry will become established in the lower Southwest, based on marri as a source of raw material. Within the ensuing decade, large quantities of small diameter pine logs will become available as thinnings from plantations. We then have all the essentials for a paper industry to follow a pulp industry. This is a much more ambitious project, requiring far higher capital expenditure than for pulp only.

Australian eucalypt pulps are not themselves suitable for paper production and require an admixture of the long-fibred softwood pulp for blending to give adequate strength factors. From 20 per cent. to 25 per cent. softwood pulp would be an average requirement for paper making.

As an indication of the scale on which wood material is used for pulping, some figures may be quoted from the Maryvale Mill in Victoria. Last year Maryvale used 50,200 loads of pine from plantations in Victoria, South Australia and New South Wales, i.e. they had

to face up to freight costs covering distances of up to 400 miles from the main plant (A.P.M. 1957).

20,000 acres of radiata pine in the Blackwood Valley would yield constantly an annual minimum of 37,500 loads of thinnings plus 82,500 loads of final crop timber, i.e. 120,000 loads of which all the smaller and lower grade material could be diverted for pulp wood reserving the larger and higher quality logs for saw timber and plywood.

As regards marri supplies to which previous reference was made, there is, within a 30 mile radius of Pemberton, ample supplies of marri to maintain a pulp industry indefinitely with a 900 tons per day intake. This figure is about 84 per cent. of the present Maryvale intake of eucalypt timbers. An economic unit could commence operations with a much lower intake, and expand as the industry developed. It could be still further augmented by hauling the marri for a longer distance, by utilising karri from thinnings in regrowth areas, and by utilising a certain amount of karri mill waste.

It is confidently expected that with the increasing population which will provide a market for paper and board products, the State can expect to see the development of integrated industry utilising both hardwood and softwood forest to the best advantage for production of saw timber, pulp, and paper within the next decade or so.

Conclusion

Forestry is one of the oldest forms of land use, and much natural forest must, of necessity, give way to other forms of land use for food production, but both agriculture and forestry must play their full part in providing the produce necessary for a well balanced economy and the welfare of our people.

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Articles

THE DYNAMICS OF PLANT BREEDING

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Plant breeding is the genetic adjustment of plants to the service of man. It seeks to bring them into better harmony with the environment in which he wants them to grow, make them more productive, easier to manage, better to use or sell, less subject to depredations by competitors and parasites, more receptive towards nature's bounty and less sensitive of her austerity. It had its earliest roots in natural selection, and to this day all, or most, plant breeding has a component of natural selection. But, one may presume, the observant cultivator has played an active part from the first beginnings of settled agriculture. He then lived close to his animals and plants, close in a truly physical sense. This can still be seen in the densely populated plains and valleys of South and South-east Asia where most agriculture is subsistence farming, where man and woman tend, sample, gather, prepare, use, often taste the products of their field, where shades of size, shape, colour, health, flavour are likely to be noticed by many observant eyes or tongues, where villages still take pride in their strains of rice, wheat or pulse.

Thus the observant cultivator throughout the ages produced the wealth of field and garden crops we now possess; and he stood at the cradle of professional plant breeding little more than a hundred years ago. Today it is the machine which is close to the plants, the cultivator is in a position of remote control. The plants themselves are refined and standardized and deprived of most of their evolutionary freedom. Evolutionary initiative and control have passed from the husbandman to the professional scientist. Basic knowledge of heredity supplements observation and supplants tradition and pragmatism: "Evolution by the will of man" (Vavilov 1935) is becoming evolution by the knowledge of man.

Yet even in our day this whole dynamic sequence can be witnessed on rare occasions, especially where wholly new evolutionary opportunities present themselves, as in the migrations of man and plant from the old world to the new. This is the case in the domestication in Australia of subterranean clover, *Trifolium subterraneum*, a component of "natural" pastures in southern Europe and North Africa and a chance introduction to Australia (cf. Frankel 1954). Its potential value as a legume for sown pastures was recognized by a South Australian farmer, A. W. Howard, in 1889. It was brought into cultivation in the early years of this century and now covers some twenty million acres of sown pasture. A number of strains have been selected from collections in the field, and today it is the subject of extensive breeding operations in which physiological as well as genetic techniques—including radiation induced

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mutation—are used. Domestication, selection by the cultivator, and plant breeding by sophisticated modern techniques are telescoped within a bare half century.

This paper is not concerned with the evolution of plant breeding methods, but with the elements of change, the forces which condition this evolution. Plant breeding dynamics are viewed in terms of four "elements of plant breeding" which are arbitrarily segregated for descriptive purposes but which are clearly overlapping and interacting. They are: 1. breeding purpose, 2. object of discrimination, 3. raw material, and 4. breeding and selection method. Naturally this discussion is confined to plant breeding as a deliberate, professional pursuit and therefore in the main restricts itself to the last hundred years or less.

The Dynamics of Breeding Objectives

The nature of the objectives is conditioned by the physical, biological, technological, economic and political determinants of husbandry and utilization. Each of these is subject to dynamic changes; and there are complex interactions, with their own dynamic consequences.

Degrees of Adaptability

Not every change in environment requires a corresponding genetic adjustment; the need will depend on a multitude of factors among which the nature of the change, the economic and technical state of the region, of the industry and of the crop, and the suitability of existing types are the most obvious. As has been known for a long time, some varieties are more adaptable to change—we would now

TABLE 1

Examples of dynamic changes which affect plant breeding policies.

Determinants		*Nature of change*
Physical and biological	geographical	plant introduction, crop expansion
	edaphic	soil fertility, soil erosion
	biotic	weeds, diseases, pests
Technological	agricultural techniques	farming systems, rotation, cultivation, irrigation, engineering, fertilizers, herbicides, therapeutants, conservation, harvesting
	utilization techniques	developments in secondary industries—bread, dairy, paint, plastics, textile, etc.
Economic and political		availability, price, markets, tariffs, import or export restrictions, subsidies, wage policies, labour supply and conditions, supply of agricultural requirements, etc.

say homoeostatic—than others; plant breeders refer to "all-round" as against "specialized" varieties.* The terms are used in an ecological sense to indicate the performance level of a variety over a greater or lesser range of environments. The adaptability of an "all-round" variety fits it to succeed over a geographical range of some magnitude, including a diversity of edaphic and climatic conditions, which exceeds the degree of adaptability required to meet seasonal variation in any one habitat. "Specialized" types by definition are superior to the former in a narrower range of habitats, but equal or inferior beyond.

Let the optimal adaptability over a region R be called the *general adaptability A* which can be regarded as an integration of the optimal adaptabilities in all the n sub-regions r_n, each with a uniform environment and hence subject only to variation between seasons; the latter may be called *local adaptability a*. The genetic adjustment to bring about the respective adaptability levels can be denoted

$$A=D+T+P+S+B+I$$

$$a_x=t_x+p_x+b_x+i_x$$

where adaptability is broken up into fractions due to day-length D, temperature T, precipitation P, soil S, biotic factors B, and interactions I—capitals indicating variations between subregions and between seasons, small letters seasonal variation within subregions. With R more or less uniform for D (or neutral for photoperiodically non-reacting plants), the effective difference between A and a will depend upon S, and on the relationships between T, P and B on the one hand, the individual t, p and b's on the other.

Specialization Versus Adaptability

Such distinctions are real enough though the nature of adaptability eludes us. Plant breeders tend to set great store by adaptability and it is more customary to evaluate crop varieties by their mean performance over a region representing a range of environments, than under closely defined ecological conditions as found in a smaller district. Yet, to be sure, the more "specialized" type would be preferable under these conditions in which it excels; and *pari passu* there are likely to be optimally adapted types for every ecological niche. That this is not mere theory can be seen in any horticultural seed list, where the many shades of differentiation are designed to satisfy a multiplicity of market requirements—including those set up by our thirst for novelty.

More objective confirmation comes from oat variety tests in nine regions into which the state of Iowa was divided (Horner and Frey 1957). The variety x location interaction was progressively reduced when the state was diviled into two, three, four and five subregions. This constitutes a *prima facie* case for a subregional diversification of variety recommendations. Since the varieties included had been selected on the basis of their overall performance, with selection for subregional adaptation the effect might have been even greater.

On general principles there is then a case for a steady refinement of specialized adaptation. But in each individual case the appropriate degree of specialization is determined by the agronomy and biology of the crop: horticultural plants may justify maximum specialization, pasture plants require maximum adaptability; breeding systems circumscribe needs, and opportunities, for specialized fixations.

But beyond these determinants which are intrinsic to the crop, there are those intrinsic to the social and economic state. Specialization implies subdivision, hence multiplication of scientific effort in quantity, and, one may expect, in depth. We may visualize two countries, similar in size and natural features, one undeveloped, the other highly developed. The former may have one breeding centre with some regional tests, the latter would be subdivided into ecologically defined subregions, each with its breeding centre and subregional test series. Thus the degree of the ecological

*A simple model of a biological system with definable grades of adaptability would be a series of genotypes with resistance to an increasing number of biotypes of a parasite.

specialization attainable in any one region is subject to the dynamics of its scientific and technological resources.

Clearly these dynamics are interacting; a scientifically backward or stagnant community cannot for long sustain intensive industrial development. But on a narrow front such unbalance is common experience; one scientific or technical development may outstrip another on which it in part depends. In the United States and some countries of Northwestern Europe, plant breeding is closely attuned to agricultural development. Any economic plant, whether important, secondary, or merely under consideration, is subjected to adaptation and improvement, and any changes in production or utilization techniques impinge upon this process. This is far from being the case in Australia, and that applies to most of our crops, including the most important ones, over the greater part of the continent. Pasture plants in particular have been the breeder's Cinderellas, and until recently none have been adequately tackled. We cultivate the strains of subterranean clover which were discovered by the founders of the crop, and we have scarcely got beyond the strain of phalaris which is descended from the first introduction plot at Toowoomba, seventy years ago. We even continue to import pasture seeds from New Zealand and the United Kingdom, without a serious attempt to breed strains attuned to our so very different environments, although this would not have been a difficult task. Even in wheat breeding, where Australian plant breeding has scored its greatest successes, agricultural practice and commercial interests demand adjustments as yet not in sight: we lack varieties suited to higher rainfall and fertility conditions where wheatgrowing is on the increase; nor do we have varieties specifically selected to satisfy the various quality requirements of our existing and potential export markets. Those shortcomings are primarily due to an insufficiency of technical and scientific resources, but secondarily to the intrinsic difficulties of prediction.

The Dynamics of Prediction.

A time lag between conception and production is intrinsic in biological as in industrial processes. But in plant breeding this gestation period is so extended that it has peculiar consequences and makes particular demands on prescience. The plant breeder needs to project his mind a decade or more ahead, lest he incur the risk of breeding for past rather than for current purposes. Not many economists and agronomists are prepared to venture the calculated guesses he requires; and though genetics conditions him to think as readily in terms of future as of past generations, the plant breeder all too often lacks the factual information to guide him in this vital discernment of breeding purposes relevant to future needs. Where there is considerable uncertainty of future needs or prospects, adaptability, in terms of production and of utilization, may be a long-range advantage, though a short-range disadvantage.

Environmental Versus Genetic "Cures".

It should be realized, however, that genetic adjustment is not the only answer to environmental stress; the alternative—and one which suffers from a lesser developmental time lag—is an adjustment of the environment itself (cf. Frankel 1954). Here are some examples of such alternatives:

	Heredity	*Environment*
Diseases:	resistance	therapeutants
Weeds:	competitive ability	cultivation, herbicides
Nutrients:	nutrient requirement or utilization	fertilizers
Climate:	drought resistance	irrigation

An indication of the way in which a "climatic lesion"—to adopt James Bonner's phrase—can be made to yield to environmental therapeutics may be the recent discovery that a foliage application of gibberellic acid may induce new growth of grass during the colder parts of the year (Leben and Barton 1957).

Whether adjustment of heredity or of environment should prevail will depend on the economic, technical and scientific aspects of the case. Clearly the two approaches inter-

act; and breeding purposes should not be formulated without consideration for environmental alternatives: a cheap and effective insecticide at least reduces or postpones the need for resistance breeding. Thus the dynamics of breeding and feeding are closely interdependent.

The Dynamics of Discrimination

The breeding objective is the highlight of a selection programme, but by no means the whole of it. For we know that selection for one character may evoke correlated responses in others (e.g. Mather and Harrison 1949). Moreover, although selection may be confined to specific characteristics, the mean expression of others may alter by chance. So we must define our attitude to the residual complex of characteristics. It may be one of indifference, it may be to maintain the *status quo* within wide or narrow tolerance levels. *Pari passu,* we discriminate between the characteristics which are the objects of selection, by varying priorities (and hence selection intensities) according to values we set and/or according to principles we attempt to recognize and apply. Discrimination between characters is thus intrinsic in any breeding, from picking up the unusual variant in field or garden, to applying a discriminant function. The nature of discrimination, as is already becoming obvious, shows infinite variation, with dynamics which are subject to those of the biological system and of the agronomic, economic and scientific environment.

Uni-character Discrimination.

We may be sure that considerations of a balance of characters or of over-all performance scarcely affected the standards of selection of the prehistoric breeders who gave us essentially the plants we cultivate. In the initial stage of any type of breeding it is the striking character or character syndrome which hits the eye (or the palate): the free-threshing wheat, the frost-resistant potato, the sweetest cane. The early selectors of what was to become sugar beet were concerned with the sugar content and little else, the mid-19th century cereal breeders with the size of the ear, the early American maize breeders with "two cobs per plant." In this manner radical, though often ill-balanced, advances were made, for natural, unconscious, or deliberate selection to consolidate.

Today, what might be called "uni-character discrimination" is restricted to specific circumstances: 1. Simply inherited, observable characters, arising as mutants or incorporated by backcrossing, i.e. with a minimum of interference with the rest of the genotype: e.g., resistance to diseases and pests; flower colours in garden plants. 2. Characters of major importance in crops in which yield returns *per se* are not an overriding consideration: e.g., shape, flower or colour of fruits: off-season production in fruits, vegetables or pasture plants; timber characteristics in forest trees. 3. Production of breeding lines with strongly expressed specific characteristics, for incorporation in adapted varieties: various quality characters or their components, e.g., high nitrogen content of wheat; components or determinants of yield, e.g., high average weight of grain.

Multi-character Discrimination.

Such special uni-character breeding plans grade into the more general, and common, type in which selection is programmed to act on a number of characters, with a minimal infringement of others which contribute to adaptation and performance. The typical breeding programme thus emerges as a multi-character selection plan, with some characters more actively engaged than others in an order of precedence and priority, grading down to those which if need be are allowed to drop. The major dynamic changes in this discriminant system are of two kinds: *a.* the conduct of multi-character selection; and *b.* the biometric, physiological and genetic analysis of the characters themselves and their interactions.

In a paper in which they examine the efficiency of these multi-character selection methods, Hazel and Lush (1942) outline a logical—and to a degree historical—sequence

of character discrimination, as follows: 1. the "tandem method" which is to select for one character at a time, to be taken in succession; 2. the "method of independent culling levels," in which levels are set for characters below which individuals are discarded, regardless of their superiority in other respects, and *vice versa;* and 3. the "total score method" which combines all relevant characters, weighted for heritability, mutual correlations and economic significance, in a single discriminant function. It is clear that the consistent element of change along this series is the increasing amount of information that is brought to bear on the process of discrimination, resulting in a progressive increase in efficiency.

The application of Fisher's discriminant function—first suggested by Smith (1936)—has been explored for multi-character selection in both animals and plants, and there can be little doubt, as has recently been shown by Hanson and Johnson (1957), that generalized selection indices can be derived which may materially increase efficiency and precision of selection. Here, it seems, biometry has given us a tool to rationalize as far as we may the effects of nature and nurture and to compromise between conflicting virtues (and failings). However, the value of a method of discrimination depends on the real significance of the component characteristics; we now must turn to a consideration of the nature of the characteristics themselves and of our changing attitudes towards them.

Character Analysis.

We have already seen that some characters are striking, express themselves in a range of environments and hence are classified without difficulty; others require encouragement by a suitable environment—disease resistance may not be recognizable without the appropriate parasite and the right environment. Such characteristics have been called "observable" (Frankel, 1947) and more often than not are simply inherited. Others, including some of major economic importance, are controlled by polygenes and are subject to a great deal of environmental variation. Such characters as a rule are not "observable" in single plants or their immediate progenies, i.e. their genetic worth cannot be reliably assessed by the kinds of tests that are practicable in the early stages of the breeding process when numbers may have to be large and tests need be simple. The pragmatic test, involving replication in space and in time, is impracticable at this stage and as a rule has to be relegated to those final stages of selection when only a small fraction of the original population remains. In these circumstances the type of selection commonly practised in the early breeding stages may very nearly be random (Palmer 1952, where others are quoted).

Biometrical Analysis.

These difficulties, it was thought, might be mitigated if the very complex characters were broken up into components of lesser complexity, yield in the cereals, for example, into plants per area, ears per plant, grains per ear and weight per grain. If this "yield structure" were established for a number of leading varieties differing in agronomic adaptation, valuable leads could be gained for selection among their hybrids. Moreover, the analysis was extended to developmental characters such as germination, establishment, tiller formation, etc., and these were correlated with yield and its components. Work along these lines was conducted by Engledow, Wadham and their associates in England, Frankel in New Zealand, Forster and Vasey and Smith in Australia. The last named author applied Fisher's discriminant function to the problem of rationalizing discrimination among plants by weighting the components of a character to increase the efficiency of selection for the character itself (Smith 1936), an approach which has been applied to a variety of organisms and problems, with varying degrees of success. Nanda (1949), using some of Smith's data, concluded that selection for yield components was no more effective in genetic advancement than was selection for yield itself. However, as Glenday and Fejer (1957) observe, "The discriminatory form of analysis provides useful information on the relationships between yield characters even where the derived function fails to accelerate progress."

Physiological Analysis.

One of the most interesting results of a "character analysis" comes from recent work on potatoes by Borger *et al.* (1956). In grafting experiments between varieties it was found that starch content and tuber size are mainly autonomous, i.e. controlled by a genetic and physiological system which is largely independent of that controlling the assimilatory capacity of the above-ground plant organs. This, the authors believe, may be due to a leaf surface greatly in excess of maximum requirements for starch assimilation. They suggest that these observations, together with others quoted, justify the interpretation that the evolution of cultivated plants is primarily an evolution of physiological "sinks" useful to man, with the leaf surface evolving with, but sometimes ahead of, sometimes behind, the storage potential.

Such observations on physiological relationships between plant organs are a far cry from the "correlations" so assiduously recorded in the first quarter of the century, or even from such biometrical ratios as the "migration coefficient" or the "tiller survival rate" which, on close examination, proved of doubtful usefulness (Smith 1936). Though foreshadowed as far back as 1923 by Engledow and Wadham, this physiological interest introduces a new level of approach in plant breeding in which pragmatic tests of variants and biometrical analyses of populations are supplemented by studies of the ecological significance and the physiological nature of variation.

The physiological approach to plant breeding is, of course, made possible by the growing knowledge of the physiology of germination, development and reproduction in plants; but to no small degree also by the pioneering of controlled environment facilities which alone can bring developmental analyses of a whole range of genotypes into the realm of practicability (Went 1957). It is now possible to assess efficiently, and relatively speedily, the optimal—or marginal—requirements, or the tolerance levels, for such factors as daylength, temperature, light intensity, light quality, nutrition, water supply, and their interactions. We can analyse a series of representative ecotypes, screen potential parents, or expose populations to environmental selection sieves which can be closely defined and reproduced at will. Such studies are still in their infancy. To bridge what is as yet a gap between the phytotron and the field, we must learn to relate the analyses conducted under standard conditions to the behaviour of the plant under natural conditions. Plant breeders and physiologists must in fact learn "to ask the phytotron the right questions."

A striking example of this new approach is a study now in progress at the phytotron of the California Institute of Technology, Pasadena. Research into the effect of night temperatures six weeks prior to harvest on fruit production in tomatoes has yielded results which are now the basis of intensive breeding operations. Professor F. W. Went found that the yield of one variety, grown at a day temperature of 75°F, trebled as the night temperature fell from 85° to 50°F, due both to more and to larger fruits. Different varieties had different optimum night temperatures. It was even found that the requirements of the plants for nutrients were also strikingly dependent on the night temperature. Next, phytotron workers proceeded to "tailor" a new tomato variety which could set abundant fruit at high night temperatures. This valuable characteristic was soon found, by phytotron screening, in an otherwise worthless Philippine strain, and it is being incorporated, by cross-breeding, into commercial varieties.

For many cultivated plants we now have information on the photoperiod and/or cold period required for flower formation. In some instances this is specific, in physiological and in genetic terms, as in the case of two varieties of rice which differ in photoperiod sensitivity, the difference being determined by one gene (Chandraratna 1953). Often, however, the system is not clear, for reasons recently discussed by Davern, Peak and Morley (1957). In the cereals, for example, the difference between spring and winter habit has been interpreted by various authors as monogenic, digenic, or polygenic; and segregation may differ according to the time of sowing (i.e. the

length of the cold period). One may feel confident that here again a phytotronic analysis would unravel the complex interactions between genotype and environment, in this case, cold period and daylength.

Biochemical Analysis.

An even higher level of specificity is reached when we advance from the physiological to the biochemical characterization of life processes or of character expression. There have been several encouraging findings recently which indicate what may be the shape of knowledge to come, and some of these, many unpublished, are quoted by Bonner (1957) in a highly stimulating discourse on "The chemical cure of climatic lesions." In essence, there are now a number of cases in which the effect of climatic factors on plant growth can be defined chemically, and some where the "lesion" can be remedied by chemical applications. The relevance of these recent observations for the future of plant breeding is briefly discussed in the final section.

Peas have an optimum temperature of about 20°C, and at 35°C they normally die. But when adenine is supplied daily they survive (Galston and Hand 1949). Similarly, the duck weed, *Lemna,* dies at 30°C, but thrives at this temperature when supplied with adenosine (McCane unpublished data). The dry weight of Cosmos, grown at suboptimal temperature, will be increased by 50 per cent if supplied with thiamine (Bonner 1943). Winter rye requires a cold period for normal flowering; but Highkin (unpublished data) found that the leachate from vernalized rye, when supplied to non-cold-treated seed, replaces cold treatment; so far the chemical substance has not been identified. Lang (1956) found that gibberellin induces bolting in otherwise non-inducted long-day or biennial plants, and Lang *et al.* (1957), that an extract from the growing endosperm of the Cucurbitacea, *Echinocystis macrocarpa,* had similar effects. Gibberellic acid reduces the dormancy period of *Arabidopsis* (Kribben 1957).

Here it is relevant to observe that what one may call "genetic lesions" have been found to be subject to "cures" by identical, or similar, substances. Dwarf mutants in maize are restored to normal growth by the addition of gibberellic acid (Phinney 1956). In *Arabidopsis thaliana,* a chlorotic mutant is completely cured by thiamin, a temperature (above 27°C) sensitive mutant by choline (Langridge 1958). We may here discern a link at the highest level of genetic and developmental specificity, i.e. between the unit of heredity and the unit of life function, which promises to result in a new level of understanding of the action and function of both.

Specificity and Significance of Discrimination.

In this analysis the dynamics of discrimination have emerged as a function of the degree and nature of specificity in discrimination. We have found a high degree of specificity at the cradle of plant breeding—the "striking character" approach; a generalized, pragmatic approach resulting from the recognition of the complexities of heredity, environment and their interactions; and recently a gradual return to specificity with the increase in basic biological knowledge. We may attempt to illustrate the dynamics of discrimination in terms of "specificity" and "biological significance" of discrimination (Figure 1).

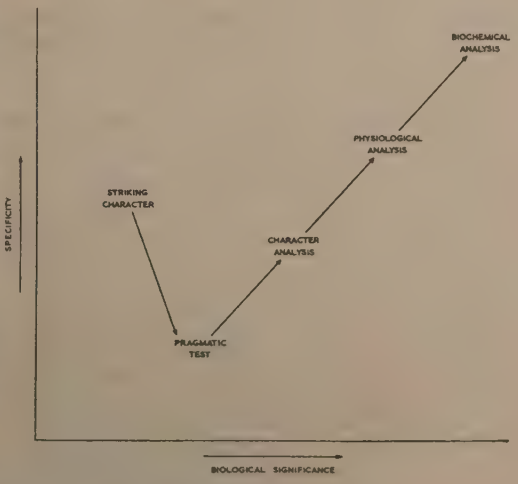

Figure 1—The dynamics of discrimination.

The Raw Materials—Elements of Change

Table 2 lists the sources of variation which have been, are, or may be used in plant breeding. Historically and biologically they form a sequence in which the elements of change are 1. the increasing scope of variation, through the progressive removal of barriers which limit variation; and 2. the increasing specificity of genetic change *a.* with regard to the desired character, *b.* with regard to the residual genotype.

The genetic limits of natural populations are the geno-types they contain. Hybridization extends these limits, subject to the barriers of crossability, linkage and hybrid fertility. Induced mutation extends the range to alleles which are rare or unknown or which are hard to combine with others (cf. a recent review by Konzak 1957). Chromosome reconstruction may circumvent the hybrid sterility barrier and surmount the barriers imposed by lack of chromosome homology or by localized chiasmata.

Specificity of the desired genetic change clearly increases in the same direction. In categories A and B we select the genotype as a whole, in A as presented by nature, in B as reconstituted by our choice of parents. C(i) and D(ii) reach the maximum of specificity, the first in reconstructing a gene, the second a chromosome segment, hence with the minimum of interference with the residual genotype. C(ii) as yet is insufficiently understood, D(i) has so far not been attained.

The Dynamics of Breeding and Selection Methods

Breeding and selection methods are determined by the breeding system and influenced by the aim and method of crop production and utilization. Hence they show great variation from crop to crop and from region to region. In general they are subject to the development of the mathematical theory of selection; but this analysis will have to be left to others. Perhaps the most striking biological element of change is the degree of genetic stability—or lability—in the product of selection (Figure 2). The diagram renders a simplified picture of the dynamic changes, the east-west axis representing the degree of

TABLE 2

Sources of variation used in plant breeding.

A. Natural populations
   - (i) Land races: populations subjected to a period of natural, but not, or not recently, to deliberate selection
   - (ii) Introductions

B. Hybridization within and between A(i) and A(ii)
   - (i) Intraspecific
   - (ii) Interspecific or intergeneric
     - (a) at original ploidy
     - (b) at higher ploidy

C. Induced mutation
   - (i) Specific changes: erectoides in barley (Gustafsson, 1947)
   - (ii) Undefined changes: yield increases (Gustafsson and Nybom, 1950, Gregory, 1955, 1956)

D. Induced recombination
   - (i) Breakage of close linkage (?)
   - (ii) Reconstitution of chromosomes (Sears, 1956)

stability, the north-south axis the historical sequence.

In the early stages of plant breeding, "purity of strain" was a major aim in its own right. A more functional attitude has grown up in recent years, with the recognition of the biological significance of "purity." In self-fertilized plants, line mixtures have been advocated (e.g. Gustafsson 1953), and Suneson (1956) found that "composite crosses" —i.e., populations derived from a great diversity of inter-crossed parents—may yield better, and more consistently, than the best standard variety. In cross-fertilized plants purity is limited by in-breeding tolerance and by the facility with which mating can be controlled.

Increasingly, purity has come to be regarded as a necessity rather than an asset. It is necessary—within limits—as a guarantee of performance, the more so the greater the value of the individual unit, or the need of uniformity of the product. The great advantages of adaptability inherent in a less homogeneous population have been discussed repeatedly (e.g. Harlan 1957). No doubt an optimal balance can be struck in each individual case, and the trend of development in breeding methods has been to provide a controlled measure of genetic heterogeneity.

The New Specificity

We have seen throughout this discussion how the recent developments in technology and science are leading plant breeding towards a greater specificity of aim, of discrimination, of materials and methods. For the most part these leads as yet are merely signs or beginnings.

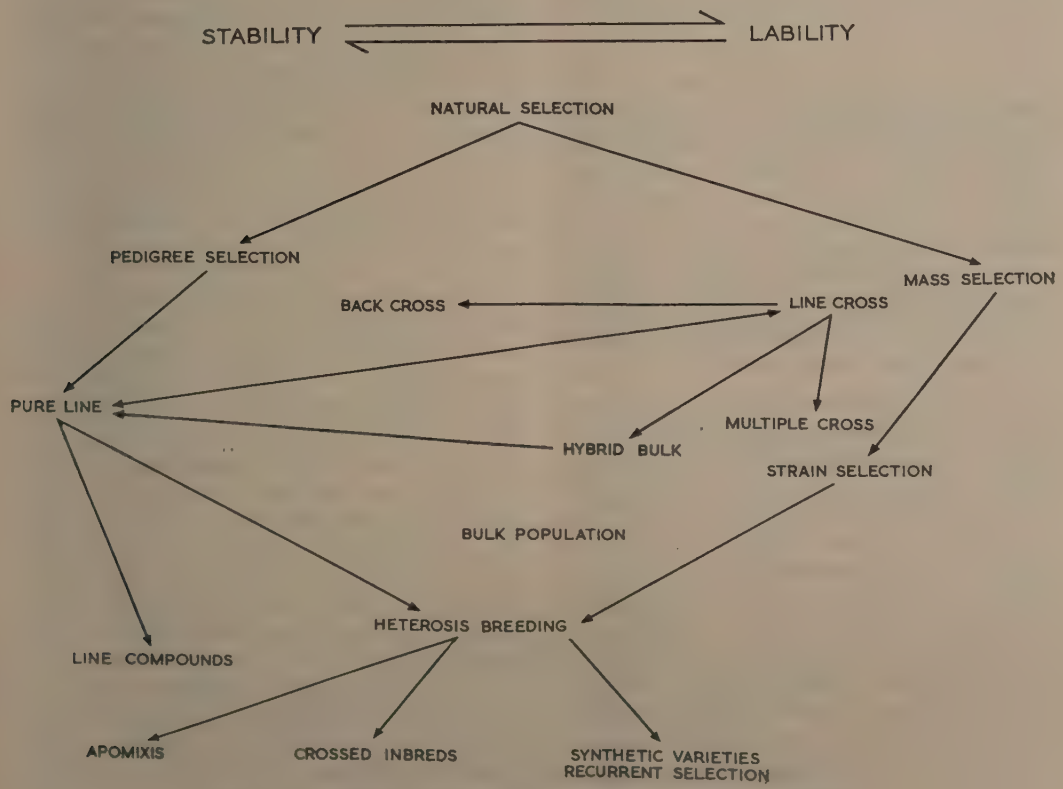

Figure 2—Breeding methods: the dynamics of genetic stability.

We are on fairly solid ground where we attempt to fit the plant to its specific economic environment created by industrial developments. Wheat once used to be the raw material for bread and cake and little else; and these were baked by experienced tradesmen capable of adjusting their methods to the vagaries of the local flour. Today wheat is used in various types of bread made by machines which lack the tolerance and adaptability of the experienced hand; it is used in biscuits of many kinds, in pastes, in starch and gluten manufacture. Tomorrow it may be used, like maize, in a variety of chemical industries. Each makes specific demands. To satisfy these the breeding material is tested in small-scale models of various industrial processes, or in empirical tests which show correlations with industrial performance. However, we lack as yet an understanding of these various qualities in physical and chemical terms, which alone would facilitate generalizations and predictions on quality characteristics.

When we attempt to delineate specific natural environments, we are faced with greater difficulties. We know a good deal about individual factors which make up the environment; but we lack the integration which would allow us to encompass the environment as a whole. Yet even now a wealth of information is emerging from soil, nutrition, ecological, climatological and microclimatological studies awaiting to be related to corresponding plant responses.

At the same time we are learning to interpret these responses in the analytical terms of basic life functions, rather than in the pragmatic terms of survival and performance alone. The aims are clear enough, as expressed recently by Morley and Frankel (1958): "An ecogenetic analysis should examine the relative significance of different kinds of characteristics in establishment and survival. It should distinguish criteria essential for ecological success from those which, while perhaps useful in classification, play a minor role in the performance and survival in space and in time. It should seek to understand the physiological determinants of success or failure and the genetic control to which they are subject. Knowledge such as this should give direction, understanding and strength to the synthesis of new plants for arrays of environments." In each individual case the application of these principles will as yet raise problems of procedure and techniques: we must learn to ask the right questions and to incorporate the answers in our breeding procedures.

The contribution to plant breeding which is to come from the biochemistry of plant growth is more problematical and, one may presume, distant. Yet an understanding of the nature and detailed action of the growth-controlling substances would revolutionise plant breeding practice, especially if, as may be expected, their genetic controls are revealed to be relatively simple. Here indeed our striving for specificity would reap its supreme reward.

High hopes extend in the field of physical manipulation of genetic specificities. Yet in spite of thirty years' background, including extensive work during the last ten, we can not as yet clearly delimit the potential of induced mutation. The evidence shows that in many instances we can induce a variety of mutants of potential economic usefulness. We may expect that the specificity of mutagenicity will increase with a greater range and better knowledge of mutagens and their mode of action.

Induced "recombination" has been successfully accomplished, as we have seen, between non-homologous chromosomes, through the translocation of a chromosome segment from one to another chromosome. This transfer can reach a high level of specificity if the translocation carries sufficient genetic markers. As yet there is no definite evidence that recombination between homologous chromosomes, i.e. crossing-over, can be increased, and, especially, that close linkage can be broken by radiation, which obviously would be of the greatest value in plant breeding procedure. It has been recently shown, however, that calcium and manganese deficiency (and an excess of calcium) may increase chiasma frequencies in a higher plant, *Plantago ovata* (Paliwal and Hyde 1957). The mechanism of the phenomenon is by no means clear, nor

is as yet its application to plant breeding techniques in sight.

Conclusions

Vavilov, in "Theoretical Bases of Plant Breeding," describes plant breeding as an art, an agricultural industry, and a science. As an art, it produced virtually all the cultivated plants we possess; as an industry, it spread the advances of the improved crop varieties over wide areas; but only as a science has it further scope for dynamic development.

In its scientific beginnings, the basis of plant breeding was the budding science of genetics; and to this day we tend to regard ourselves as geneticists. But other sciences were absorbed into the orbit—mathematical statistics, biometrics, cytology, and increasingly, as we have seen, the sciences concerned with the *metabolism* of the plant, physiology and biochemistry. It is from the synthesis of these sciences—genetics and cytology on the one hand, physiology and biochemistry on the other—that plant breeding will derive its next, and we may expect significant, dynamic change. It is for this we must prepare our minds, our organization, our institutions, our associations.

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FACTS, FANCIES AND FALLACIES, FOR UNSCIENTIFIC SCIENTISTS

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Recent events have thrown into stark relief exciting changes in the scientific and industrial world. These changes have created a situation which was described as recently as 1956 by the *New Statesman and Nation* as an educational crisis, arising from the need for more and better scientists. It was then called "a change for which we have not yet found a name", and because its effects were not then apparent for all to see it was referred to by the *New Statesman and Nation* as an invisible crisis.

In 1958, the crisis is invisible no more. This nameless and invisible educational crisis has erupted into a scientific renaissance which raises science to a new place in the modern community. This renaissance has brought in its wake new problems which centre on the relationship between men of science and their fellow men in the modern community.

Science and scientific endeavours are emerging from a period when there was a virtual breakdown in understanding of the aims and status of science in the community. This breakdown was made evident by the inadequate resources devoted to scientific research; but there were other aspects of equal significance to which I shall refer.

I have chosen to review here some of the fallacies which affect the status of agricultural science in the modern community. These fallacies have, from time to time, been accepted by policy makers, by scientists, or by people conveying the results of research to the public. Acceptance of the fallacies has had significant effects on the concepts of what science is, what it can do, and the conditions necessary for it to flourish. The result has been a default on the part of scientists, who have failed to maintain effective relationships with the community at large.

Let us, then, consider some of the fallacies which have influenced prevailing impressions of the scope and status of agricultural science in Australia. In this context I am using the word fallacy in its sense of a "false or erroneous idea", a "deceptive or false appearance which misleads the eye or the mind". That is, it misleads the eye or the mind about the real nature of the world around us.

The Fallacy of the Invisible Hand

The first fallacy is that of the Invisible Hand. This fallacy prevails among many of the policy makers concerned with the administration of scientific research. Some 180 years ago, Adam Smith developed at great length the concept of what has since become known as laissez faire. One expression of this idea was his famous concept of the invisible hand which, he argued, served in some magical way to put the affairs of the nation in order so long as each individual person pursued his own interest. Thus:

> By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain; and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. Nor is it always the worse for the society that it was no part of it. By pursuing his own interest, he frequently promotes that of the society more effectually than when he really intends to promote it.

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In more recent times, I suspect this theme has reared its head again in the saying, "What is good for General Motors is good for the country". But all the evidence of modern life indicates that, while individuals must be granted freedom to pursue their own interests, there is also need for planned action by some central authority to ensure that communities take action to achieve some goals which individuals alone would never achieve. There is no invisible hand which will ensure that modern communities will achieve any particular goal, far less recognise the importance and significance of science. There is no invisible hand which ensures that money and resources will be made available to any research agency which has no regard for the need to keep others informed of its work.

One can turn, by way of example, to the Australian universities system, which had reached a point of virtual breakdown prior to the inspired intervention of those who organized the appointment of the Murray Committee.

As the Committee reported (p. 91) in its stringent comments on internal administration in Australian universities:

—the universities should, in asking for help from the only sources which can sufficiently support them, keep clearly before their minds the considerations in regard to the national interests which are bound to weigh with governments, and with those considerations in mind to seek to present a coherent picture to them of what the universities are doing, and seek to do, for the Australian community.

Writing of what it refers to as the need for "a radical reconsideration of policy making procedures and machinery in the university world", the Committee points out that:

University planning and policy making call for the marriage of academic experience and insight with a knowledge of affairs and business good sense.

In other phases of scientific administration in Australia, the need is no less urgent than it is in the universities for "knowledge of affairs and business good sense"—in short, for an unscientific attitude.

The Murray Committee also pointed to the need for the Vice-Chancellors and Professorial Boards in each university to sort out their relationships with one another, so that policy making could be more effective. This viewpoint emphasises the need for the universities to conduct a much more active programme to convey the importance of their work to the communities around them. The success in rallying financial support by the few university faculties who have acted in this way shows how willing the leaders in other parts of the community are to assist them. In large part the fallacy of the Invisible Hand among scientists has contributed to the failure of private industry in Australia to participate more actively in scientific research. It has led to the fallacy that science generates its own goodwill.

The Fallacy of the Single Sciences

This fallacy, to be found among the scientists actively engaged in research, arises from the extreme specialization in each of the separate scientific disciplines that is so much a part of university training nowadays.

The fallacy of the Single Sciences arise when specialists in different fields, because of laziness or sheer ignorance of the contributions which can be made by other specialists, do not feel it worthwhile to work together so as to take advantage of progress in each specialised field. Occasionally one hears of workers backing away from a problem because it is beyond their specialised field, even when their entry to it is necessary if the contributions by other specialists are to be as effective as is possible.

If you doubt me, or think the plea too obvious to be worth worrying about, read Norris' stimulating and stringent review of the status of knowledge of the *Rhizobium* symbiosis (1956). He shows how the fallacy of the single sciences, together with too great a dependence on inductive methods, has led legume bacteriologists to make an awful mess of the concept of species classification of these bacteria. Norris says:

There is a widespread tendency to speak of 'legumes' when what is in mind is clearly 'clovers'. There can be no guarantee that what is true of clover is true also of the 10,000 species of legume that have still not been examined. If bacteriologists tend to generalize rather too widely in their discussion of symbiosis they may take comfort from

the fact that agrostologists and agronomists are frequently more serious offenders. Their heritage is a knowledge of clover leys, and with them 'legume' and 'clover' are all too frequently synonymous.

He then points the way to an escape from the dilemma by suggesting that:

With knowledge of the cross-inoculation habits of bacterium and host, and of the specific status of the bacteria, in a state of indecision, it is important that other avenues of thought should be explored in an effort to understand better the problems of symbiosis. One of these avenues that might be expected to lead to some understanding of the problem but which has been almost entirely neglected is an enquiry into the botany, both past and present, of the Leguminosae.

The increasing specialization within each discipline seems to be inevitable from the viewpoint of progress in that particular field. Whether we wish it or no, this specialization is in fact occurring. But this change creates the need for more cooperation by different specialists when solutions are being worked out at the applied level. Obvious as this may seem, it still serves to explain many of the impasses which have been reached in current agricultural research programmes. Current discussions relating to methodology in soil science provide another example of this (Butler 1958).

But, apart from its effects on scientific methods, this specialization or fragmentation has disastrous effects on scientists if we take a broader view of their role in the community, as we must when we come to apply the results of agricultural research in practice. As Sir Ian Clunies Ross (1952) has said:

. . . while scientists and professional men, by virtue of their numbers, education, and the importance of their functions, should take a vital part in the life and thought of their times and in all those aspects of human relations which are concerned with administration and government and the operation of the social organism, they are not only ill equipped but, as a result of their university training, so permanently mutilated that it is idle to expect anything of them.

Similarly, *Nature* (1957*b*) records the view that:

Our intellectual disciplines are drifting apart, leaving at the centre only a void that lays bare a fundamental weakness in our present day civilisation. In this situation a key position is held by the universities . . .

Yet, at the universities, the various disciplines are becoming more and more vocational.

It is for the agricultural scientist to recognise the significance of these observations to his own circumstances. First, his strength lies in a willingness to draw on the work of a whole range of specialists working in many fields. Second, he needs to recognise the common ground—the common base of scientific method—which exists between physical, biological and social sciences, and to widen his range of interests to embrace them all when dealing with the application of research results in practice.

The battle for recognition of the social sciences has been won in part on methodological grounds. The social sciences which have quantified their variables have made most progress in recent years. The essence of scientific method is the forming of hypotheses, the step from the hypothesis to the definition of the experimental design that enables observations to be recorded so as to prove or disprove the hypothesis, and the recording and interpretation of these observations. In social sciences, the essence of the experimental method can be taken over if the procedures of hypothesis testing are used as a basis for observation of quantative relationships in the social environment around us (Salter 1946).

In Australia agricultural scientists have failed to see how social science could help them meet the problems which they are facing. The effects are evident at the research level when problems of methodology are involved. For, ironically, it is by contributions which improve research methodology that the social sciences—after learning to quantify their variables in the manner of the physical scientists—point the way to an escape from the predominantly inductive method of research which has served agricultural science so well in the past. Dependence on inductive method is no longer adequate in the present state of scientific knowledge. It leaves scientists baffled and ill-equipped to handle problems which involve abstract thinking. In the field of animal nutrition much current argument centres on this very point.

But the effects of neglect of the social sciences show up even more when advisory officers are provided with research results which do not provide an adequate basis to develop an extension programme. The uplift which extension services have received in recent years has been founded largely on the work of social scientists, who have pointed the way to better techniques of communication between extension officers and primary producers. One finds among individual agricultural scientists a ready willingness to acknowledge the importance of work of this kind. What seems to have gone wrong is that when decisions are being made which define fields of work, the body corporate of natural scientists too easily loses sight of the significance of the social sciences.

Thus, the Single Sciences fallacy has hindered the development of science in Australia. It has done this indirectly by its effect on the breadth of outlook of scientists, and directly by discouraging the very forms of research which would hasten the acceptance and application of the findings of science in our modern community. All this has contributed to the problems of extension work in Australia, and its low status compared with research activity.

The Fallacy of the Foolish Farmer

The fallacy of the Foolish Farmer leads the agriculturist to act as if he knows better than the farmer what is good for him, and to believe that farmers who don't adopt his recommendations are foolish indeed. This fallacy is established, to a varying degree, in the minds of research workers concerned with applied problems which are encountered by farmers.

The fallacy of the Foolish Farmer leads the scientist to deplore what he considers to be the slow rate of adoption of technological change, and to deplore the indolence and slothfulness of some farmers.

In its extreme form the Foolish Farmer fallacy finds its expression in quite a different way. Rather than too slow, one now finds the complaint that farmers are too hasty. In their desire to take full advantage of new discoveries they sometimes by-pass the established channels of communication from research workers to the extension officers. Farmers rush to apply minor elements or feed vitamins, sometimes before the necessary trials in each local environment have been conducted. These developments emphasise the need for review of the effects of commercial firms on the adoption of new techniques of production by farmers, and the effects of these firms on the relationship between research and extension workers.

Failure to take account of the real motives behind decisions by farmers is based on the fallacy that they all have, or should have, identical motives when they set about their farm operations. Advice about mechanization, pasture improvement, fodder conservation, drought feeding or the need for structural improvements, is sometimes given in a way which suggests that the farmers are all motivated by the same desire to increase income. But significant differences exist between farmers as to problems of raising the necessary capital, bearing the risks involved, or achieving the higher level of management which the change requires. Quite often the position is set out in the form of a little sum, which may even take the form of a budget of costs and returns. If one believed the sum, the farmer would indeed be foolish not to plunge headlong into the proposal. But so often the sum does not portray the position as the farmer sees it; so often the scientist has to move beyond the firm basis of his scientific knowledge to shrewd guesses as to what motivates the particular farmer concerned. Instead of relying on shrewd guesses, we need to widen the frontier of scientific knowledge to cover problems of human motivation. Then we can increase the range of circumstances in which it is feasible to take advantage of such major research findings as those relating to farm mechanization, pasture improvement and drought feeding.

At present, advice to farmers cannot be adjusted on a scientific basis to meet the needs of individual farmers. We need a classification system which ensures that farms (which includes the farmer(s) operating each one) classified in the same category each

react in the same predictable way to an opportunity to introduce a new technique of production (Case and Williams 1957). One group of farmers would do it; one would try, but fail; other groups would not do it, for various reasons related to the agronomic, economic and social characteristics. Such a classification would provide a sound basis for an extension programme, with advice adjusted to the needs of each category of farmers. Over a period of time, and under the influence of constantly changing economic and social events, farmers would move from one category to another, but there would be enough stability to make the classification useful.

In one sense the social sciences are still at the stage that the natural sciences were in prior to the Linnean system of classification of plants and animals. Can you cast your mind back some 222 years, to 1736, when Linnaeus first set out the principles for defining genera and species? Create in your mind the confusion which would exist if you did not have the Linnean system of classification to help you handle the large number of plant and animal types encountered in nature. A position such as this still applies for extension workers when they attempt to interpret the problems encountered by individual farmers. They have, of course, a rough and ready classification system founded on their years of experience, but we need one founded on scientific enquiry which can be used by less experienced extension workers.

Thus, the fallacy of the Foolish Farmer arises from a lack of understanding of the different kinds of resistance to changes in production methods which exist within different individual farms. Fortunately, the fallacy is dying out as more knowledge of the goals and motives of farmers is accumulated. Acceptance of the fallacy has prejudiced the the prestige and status, in the eyes of farmers, of many of the people whose task it is to convey scientific research results to farmers.

The Father Fixation Fallacy

Fallacy No. 4 is the Father Fixation fallacy. Again, this is a fallacy which becomes important among those concerned with administration of our scientific services, though scientists are culpable to the extent that they condone the fallacy in their everyday work. It has grown up in part as the result of the system of financial relationship between the Commonwealth and States which has developed in Australia.

The Father Fixation fallacy is that the source of financial support is also the source of superior judgments about the needs for and adequacies of alternative scientific research programmes. Linked with this is the fallacy that the mechanism by which funds are provided from levies on the production of different rural products is also the best channel for the control of the research programmes once they are under way. This fallacy leads to the belief that it is possible for those who are using the products of research to make judgments about the way in which research efforts are to be directed. Perhaps the Father Fixation fallacy has been fostered by the evident signs of the widespread acceptance of the Foolish Farmer fallacy among scientists. This has led industry leaders in different rural organizations to take a more active part in the planning of research programmes.

But acceptance of the Father Fixation fallacy is a default in understanding of the very nature of scientific enquiry, the essence of which is the need for freedom of operation once the subject of enquiry is determined.

There are still some government agencies engaged in so called research which have major responsibility for administration of government policies of one kind or another. Similarly, there are industrial firms which conduct their own scientific investigations and which are also, of course, concerned with sales and technical services. In such cases it is desirable that the operational phases of research activity be separated from those responsible for policy and administration, who are watching and waiting for the outcome of the enquiries.

Failing this complete independence, the intervention of the policy making influence in the research project will destroy the essential element of scientific enquiry. Then it becomes vital that the enquiry should not be called

scientific research in the sense in which we are using it here. By way of illustration, there is some evidence of a rapid turnover of agricultural science graduates out of positions in private industry. One reason may be that the concept of research in the mind of the graduate when he accepted the position is quite different from the concept in the mind of the employer who is looking for a graduate to do what he calls research. Work of this kind fails as research not because it relates to "applied" problems, but because the mind of the research worker is inhibited by the environment in which he works.

Great administrative skill is required to steer a course which leaves the scientists free, but at the same time ensures that the work is addressed to problems of practical significance. It then becomes a responsibility of our research institutions to achieve the prestige which ensures that the controllers of purse strings will leave them free to conduct research without pressures for quick results, and free from pressure to disrupt established programmes of work.

Problems of this kind have caused increasing concern in recent years in the United Kingdom. A recent issue of *Nature* (1957*a*), comments on what is called the piecemeal approach to scientific and industrial matters which has steadily undermined the confidence of the scientific community as to the competence and sincerity of successive governments in such matters. The article then says:

> If the scientist is to cooperate, the Government must inspire his respect. This is not to say that the proper application of science to the needs of the nation can be determined by scientists alone; rather, the best scientific advice will not be available unless due regard is had to the conditions under which such advice can be secured and made effective.

The essence of an escape from the Father Fixation fallacy therefore, is to choose the research team carefully, provide the research workers with the resources they require, and display and maintain confidence in their capacity to conduct research.

Thus, the Father Fixation fallacy has, in its turn, led to some misunderstanding between scientists, governments, and the remainder of the community. Sufficient care has not been taken to establish and convince the public of the difference between uninhibited scientific research, and the particular form of enquiry which emerges when the research is conducted in the knowledge that policy interpretations are always due to be added on to the results of the enquiry.

A Plea for Unscientific Scientists

We have thus built up a rather imposing list of fallacies—the Fallacy of the Invisible Hand, the Single Sciences Fallacy, the Fallacy of the Foolish Farmer, and the Father Fixation Fallacy. Each of them in its own way and in its own time, has been accepted to a varying extent by different people in the scientific hierarchy. Each has thereby influenced the nature and extent of scientific research in Australia's rural industries. If we are conscious of the effects of these fallacies we may be better able to guard against them. Then we can take full advantage of the opportunity provided by the upsurge in scientific activity which is now gaining momentum in Australia and throughout the Western world.

At first sight the mere existence of this renaissance might suggest that some of my fallacies are themselves fallacious. For what does it matter if these fallacies prevail in the minds of some scientists if the atom splitters and sputnik manufacturers can be relied upon to convey to the world at large the contributions of science to modern life?

The answer rests with the nature of scientific enquiry itself. So long as scientists do have to rely on the practical application of the work of atom smashers and sputniks to convey to others the significance of their contributions, for just so long will they have forfeited their responsibility to preserve the status of science. It is the method of scientific enquiry and the pursuit of knowledge for its own sake that must be the rock on which we rest.

In his report for the year ended June 30, 1957, C. P. Haskins, President of the Carnegie Institution of Washington, suggests that we ourselves, the restless, insecure, anxious, vital participants in the present era of contemporary intellectual development may well be looked back upon by other men, sometime, some-

where, as inhabitants of a Golden Age—"half-knowingly, half-unrealising, we are living in proximity to one of the most astounding Golden Ages of all time". Even so, we need constantly to remind ourselves of the "deeper unities that underlie all the diversities of the scientific mode—the unities of value, of standard, of goal, of motivation", which lead to "a shared, and accepted, and dedicated way of life". Thus:

> In the event, it remains essential to recall the distinction and the interdependence between the strands—science as a way of getting things done, and science as a way of life and a viewpoint of the world. The first component needs little further emphasis than its own extraordinary achievements already bring. But the second, and inherently the more basic, element does require constant reaffirmation among us that it may retain all the vitality and the allegiance and the comprehension that are essential to its vigor. The task of such reaffirmation is especially important not only because this is the more subtle as well as the more fundamental side of science, and therefore less casually appreciated, but also because it is in constant danger of being overwhelmed by its lusty partner and so lost to view.

All this is not intended to deny the practical significance of improved methods of production—more and better mousetraps—which can be developed as a result of scientific research. What it is intended to do is to highlight the difference between the two distinct justifications for a scientific research programme. On the one hand, we may rely on the nature of scientific enquiry itself, and on the other hand we may rely on the practical significance of new methods of production which spring from those enquiries. Acceptance of the second alternative to the exclusion of the first is a major default on the part of scientists. It leads them to accept fallacies which have prejudiced the whole concept of science which the scientists as a group have conveyed to the remainder of the community. Let us have research into practical problems, by all means. But let us keep our concept of, and our justification for, work of this kind separately from our concepts of and justification for, science and scientific enquiry.

Lest this be thought too unrealistic in our modern world, let me again refer to the words of the Murray Committee. Writing of the responsibilities of universities, the Committee describes the two important functions of education and research, and then (p. 11) refers to a third function in these terms:

> They are, or they should be, the guardians of intellectual standards and intellectual integrity in the community. Scholars and scientists who spend their lives in the search for knowledge should, at least in their own spheres of inquiry, be proof against the waves of emotion and prejudice which make the ordinary man, and public opinion, subject from time to time to illusion and self-deceit. There are obviously many spheres in which the scientist can keep us from self-deluding error—in the attempted final conquest of the air, for instance, or in matters of national defence; and there are also fields of at least as great importance, ultimately indeed of more importance because they more closely affect the life of the mind and spirit, where the historian, the lawyer or the economist, to mention only a few of the other spheres of academic scholarship, must join with the scientist to make us less hypnotized by what is ephemeral and temporary and more sensitive to the fundamental laws which govern human destiny. The preservation of human integrity in facing truth and the demands of justice is the most exacting task which a nation can impose upon itself. It can hardly be achieved with completeness by the individual man or woman.

This heavy responsibility on the universities can, of course, be shared by others. My plea therefore is for some unscientific agricultural scientists. They need the courage and skill to move beyond the firm base of their research results into the sphere of influence which determines the role which their science is to play in modern life, without succumbing to the fallacies to which I have referred. I say unscientific because in the world of social interactions between men, the scientific method is unsuited to the task of hammering out the policy decisions which are so necessary if scientists are to be given the means to fulfil their tremendous responsibility to society. And, as Sir Edward Appleton (1957) has remarked, "Science is too serious a matter to be left entirely to the scientists". I say courage because it is so easy to allow oneself to be dominated by the system of institutions through which scientific research is conducted and through which research results make their impact on everyday life. Instead of mastering

this system, too often we have been its servant.

With few exceptions, Australian agricultural scientists, in common with their colleagues in other branches of science, have failed to rise above the responsibilities of their official positions in the institutional system through which agricultural research is administered. Agricultural scientists have forgotten that a house divided against itself cannot stand. Academic workers have been academic, bureaucrats have remained bureaucrats, fundamental research workers have stayed fundamental. All this may well be if we consider only the research itself. But who is to determine the status of science in the community if all are too timid to step beyond the bounds of responsibility involved in earning their daily bread?

In the meantime, there are many side effects of this situation which cry out for attention. Extension workers and applied research workers, for example, who are the voice, the eyes and the ears of agricultural research in so far as the rural community is concerned, have remained unhonoured and unsung, and hungry for opportunity. Starved of resources, they have been left to their own devices to flounder among the inadequacies of our institutional framework. Their own devices, founded as they are on educational systems dominated by the fallacies which I have described, have so often proved inadequate for their tasks.

Conclusion

This brings us back to our starting point once again. My theme has been that under the pressure of unprecedented changes occurring at breathtaking speed in recent years, scientists have succumbed to fancies and fallacies and have thereby failed to preserve the status of their profession. Do we really understand the changes which threaten to overwhelm us at the same time as they provide such opportunities for progress? The changes have been so deepseated, and have happened so quickly, that they have been much too much for those who have mastered the technical expertise of scientific observation and language, without understanding the essence of scientific method.

Scientists have been unscientific in developing a concept of the scope and nature of scientific enquiry; they have succumbed to the Single Sciences fallacy which has unnecessarily restricted the scope of their profession; then, in their contacts with the remainder of the community, at the very stage when "a knowledge of affairs and business good sense" is required, the fallacies of the Invisible Hand, the Foolish Farmer, and the Father Fixation have all come into play. Misunderstanding of these issues has prejudiced the position of the scientist in the eyes of his fellow men, and has left a vacuum where there should be knowledge and understanding by the public of the nature of science. Worse still, this vacuum has been too easily filled by the idea that science and scientific enquiry depend for their justification on their contributions to war and material welfare, instead of on ultimately more important things, which in the words of the Murray Committee are "the life of the mind and spirit".

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Technical Articles

Brown Rot of Stone Fruits. Latent Contamination in Relation to Spread of the Disease

S. M. R. JEROME

The conidial population of Sclerotinia fructicola (Wint.) Rehm builds up gradually during the fruiting season if conditions are favourable and can start from a few early foci of infection.

Conidia are deposited on fruit within a reasonable distance from infection foci, and remain concealed among the hairs on the surface of the peaches, thus constituting a latent contamination of viable spores.

Bruising and splitting of the fruit occurs naturally during growth, and the pathogen can then invade rapidly, irrespective of the state of maturity of the fruit, thus adding to the spore population and producing more brown rot.

The probability of latent contamination causing infection is one of the most important factors to be considered. Accordingly it is suggested that a spraying programme for the control of brown rot may be more efficiently regulated if guided by a forecasting system based on the conidial population on fruits in suitable areas.

During some preliminary field investigations on stone fruits in the Canberra district concerning the incidence of brown rot (*Sclerotinia fructicola* (Wint.) Rehm) an early infection producing premature mummies from the season's young fruit was observed in one area. Thereafter there followed a slow spread of the disease in that vicinity. This spread accelerated after a good fall of rain, and a few weeks later the incidence of the disease was recorded at increasingly greater distances from these early foci. In mid-February when the main crop of peaches was nearly ready for harvesting, there occurred a sudden flare up of the disease, which was by that time widely dispersed throughout the whole Canberra district.

This sequence of events suggested that from a few early foci of infection there is a progressive build up of the pathogen's popu-

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lation, which starts slowly but may increase rapidly when environmental conditions become favourable. Such an increase of spore population would mean a correspondingly great increase in the number of spores being deposited on fruit nearby the centres of infection.

Many investigations have been made on brown rot, but the reason for its sporadic occurrence followed, at times, by extensive development have not been fully understood. Angell (1951) found that artificial distribution of spores did not necessarily result in an increased percentage of disease on apricots. More recently, Wade (1956) suggested that latent infections which subsequently became pathogenic at certain stage of fruit maturity were responsible for the outbreaks.

This paper gives evidence that infection by *Sclerotina fructicola* and establishment of brown rot among peaches can occur quickly and disastrously under natural conditions, as a result of conidia concealed on the surface of the fruits, combined with a high probability of infection. This probability is enhanced by mechanical or other superficial injury to the fruit.

Materials

The fruit used throughout these experiments came from three locations. The bulk was from a single, rather isolated, tree in C.S.I.R.O. orchard (Location 1) where five peaches were artificially inoculated by injecting a spore suspension from a pure culture of *S. fructicola* grown on potato-dextrose-agar. In addition to these, some fruit, used in the first experiment, were collected from a Canberra garden where a badly infected nectarine tree acted as the source of infection (Location 2); and from a garden in another suburb where brown rot had appeared on one tree, which was stripped early to obviate loss of the fruit (Location 3).

Susceptible apples were collected from a C.S.I.R.O. orchard, surface sterilized and used as hosts in spore counts.

The peaches used for bruising experiments came from Location 1 and were used at different stages of maturity. All fruit under test were placed in dishes lined with moist filter paper, covered with a glass sheet, and kept at 20°C. All spore suspensions and inoculations used were prepared from pure cultures of *S. fructicola* grown on potato-dextrose-agar.

Experiments and Results

Ia. Presence of viable conidia on surface of peach fruit, and their removal for spore count.

Fruit which were growing within certain measured distances of the previously infected peaches, were collected on different dates. These were peeled very thinly, removing only a minimal amount of underlying tissue: the peel was covered with sterile water in a flask and the air evacuated by means of a vacuum pump. It was then shaken mechanically for one hour, to ensure thorough washing of the hairy surface. The liquid was decanted and centrifuged and the peel was discarded.

The sediment resulting from centrifugation, was taken up in 10 ml sterile water and diluted as necessary to give serial dilution of 1, 10, 100, 1,000. Each dilution was tested on 20 pieces of apple, each piece being inoculated by one drop of approx. .027 ml per probe. The apples were inspected daily. The percentage of pieces becoming infected are given in Table 1. These results show that apples inoculated with the sediment became infected with brown rot, thus demonstrating that viable conidia of *S. fructicola* had been present on the peach surfaces and had been removed by the above method, being retained in the sediment.

1b. Relative numbers of conida in relation to distance and time interval.

The data in Table 1 show that the percentage of infections did not decrease with dilution as rapidly as would have been expected, indicating, possibly, an aggregation of conidia at the higher concentrations diminishing in degree with dilution. At the lower counts the effect of dilution approximated to expectation and it was assumed for purposes of calculation that aggregation was no longer a factor, or had reached a stable level. A relation between the percentage infected at one stage

TABLE 1

Estimation of the number of infective units isolated per peach from fruit surfaces at various intervals, of time and distance, from primary infections.

Date	Distance from infection in feet	No. of peaches	Incubation period in days	Percentage infection on apple at dilutions				Calculated minimum number of infective units units per peach
				1	10	100	1000	
Section A Location 1								$X10^3$
13/2/57	6 ft.	8	5 days	62.5	62.5	37.5	12.5	20
19/2/57	,,	8	6 ,,	86	80	43.3	12.5	59
27/2/57	,,	10	5 ,,	100	100	60	43.5	320
Section B Location 1								
15/2/57	10 ft.	6	6 days	100	25	25	0	24
Section C Location 2								
14/2/57	24 yds.	5	4 days	100	83.6	76.4	60	2,330
19/2/57	150 ,,	1	6 ,,	25	20	6.6	0	2
Section D Location 3								
28/2/57	6 ft.	3	5 days	93	86	48	30	390
28/2/57	45 yds.	5	7 ,,	77.7	28	12.5	0	7

and that at the succeeding dilution was obtained graphically. This was used to estimate the density at a high percentage infection in terms of number of dilutions necessary to reach a percentage of 7 or less, and thus the corresponding minimal number of infective units per probe at this level. The estimates thus obtained for the several dilutions, after correction for the dilution factor and probe volume were averaged. These minimal estimates were then expressed in terms of infective units per peach, and are shown in the last column of Table 1.

Infective units are defined as consisting of conidia and probably a small amount of macerated mycelium deriving from conidia which have germinated on the surface of the fruit.

The numbers on the table are relative and very approximate, nevertheless, they show that the relative numbers of conidia on the surface increased considerably over the period of the experiment (Section A) and that fruit at a distance from the infection source had relatively fewer conidia that those in the immediate vicinity of infection and that the numbers decreased with increasing distance from the source. (Sections A, B, C, D).

Examination of the results in Section B shows that, as would be expected at the beginning of the build-up period, the number of spores isolated is low; nevertheless the number when analysed on a log spore/log distance curve after Gregory (1945) indicates contamination from other sources.

2a. *Development in relation to state of maturity of the fruit.*

Five peaches at different stages of maturity were artificially inoculated with a heavy conidial suspension of *S. fructicola* by means of filter paper discs soaked in the suspension and applied at random to the surface of the peaches. Each peach had approximately 23 discs applied. This experiment was repeated several times on different occasions using various numbers of peaches and methods of inoculation. The figures shown in Table 2 indicate the general result that with a heavy enough contamination penetration will occur whatever the state of maturity of the fruit, though it may take longer to show symptoms in immature fruit than in mature fruit.

TABLE 2

Development of infection in relation to the state of maturity of peaches.

State of maturity	Number of infection centres at stated number of days after inoculation.				
	2	3	4	7	8
A. Ripe early peach	8	G.R.			
B. Nearly ripe yellow	5	9	G.R.		
C. Intermed. green	nil	nil	5	18	G.R.
D. Unripe hard	nil	nil	nil	13	No.G.R.*
E. Intermed. green	nil	nil	6	Removed for Micros. Exam.	

G.R. = General Rot

*The rot here was seen in patches, the spread was not great enough to cause coalescence into general rot. Fructification was also scanty as compared with the luxurious fructification seen in A and B.

2b. Region of first infections and differences in susceptibility of different parts of the fruit.

Invariably in the previous experiment the first infections appeared at random but always under an applied disc. It therefore seems obvious that the infection occurs irrespective of the region of the fruit, no one region being more susceptible than another; also since first infections appeared always under a disc, the infection came from the applied conidia and not from a latent infection. Microscopic examination of many free-hand sections failed to distinguish directly the method of penetration, due to the hairy surface, even after the surface had been shaved. However, reversal of the sections and staining with lacto-phenol blue showed a number of penetrations per section, none of which appeared to be through a stoma.

3. Proneness to infection of sub-epidermal tissues of peach.

Peaches from Locations 1 and 2 were peeled thinly; the flesh was sliced with a sterile knife. There were 12 slices 1 cm. thick from green fruit and 12 slices of the same thickness from ripe soft Elberta peaches. These slices were placed at random in petri-dishes and inoculated with drops of conidial suspension. All slices became equally infected, fructifying copiously. Therefore no inhibition is operative in the sub-epidermal tissue, and any lag in infection of the whole green fruit as compared with the whole mature fruit would seem to be due to the mechanical difficulties of penetration and subsequent growth of the fungus.

4. Comparison of incidence of infection in mechanically injured fruit and in uninjured fruit.

Sixty very green peaches were gathered from the tree (Location 1) four weeks after primary infection was established and separated into three lots of twenty each. A spore count sample showed that these peaches had approximately 59 x 10^3 infective units present per peach (Table 1). Lot A were bruised by squeezing in a vice, Lot B were pricked with sterile needles, and Lot C were uninjured controls.

After four days Lot A showed 100 per cent. infection, Lot B 55 per cent. infection, and Lot C no infection. These results also show that viable conidia are present on the fruit and that, under the conditions of incubation, they can cause infection of damaged fruit. The fact that all of the bruised fruit were infected suggests that the increased ease of penetration is responsible, and the differences between the three groups appears to depend entirely on the increased probability of a spore becoming infective.

5. Comparison of the incidence of infection in bruised fruit, with varying degrees of bruising and mechanical injury, and uninjured fruit.

Sixteen days after the last experiment the remainder of the crop from the tree (Location 1) was carefully harvested. Ten peaches were removed at random for spore counts which now showed average number of infective units present per peach to be 320 x 10^3 (see Table 1). The bulk was in various stages of maturity and was separated at random into three lots of approximately fifty peaches each. Lot A were dropped singly from a height of three metres on to a hard surface. Lot B were treated similarly but the drop was reduced to one and a half metres. Lot C were not treated and were used as controls.

The bruising and splitting in Lot A was considerably greater than in Lot B. All fruits were placed in dishes, 12-13 per dish, thus making four dishes for each treatment. They were inspected daily, any infected fruit being removed immediately. Table 3 shows that Lot A became 100 per cent. infected, 86 per cent. being infected within four days and the remainder, consisting of very green fruit, gradually becoming infected over a longer period. Lot B showed a moderately rapid increase of infection only 50 per cent. within four days and a final 78 per cent. after 10 days, some remaining uninfected throughout. Lot C, the untreated controls, showed a moderately constant loss by infection all the way

through, and by the end of ten days 63 per cent. had been lost by infection.

There is a significant difference between Lot A and the other two; between B and C the difference is not significant with the numbers of fruit used in these experiments. although the evidence is in favour of greater disease incidence in B than in C.

Every infected fruit in Lot C was closely inspected after removal. and in nearly every case some break. small hole. or split was seen as the centre of infection; some of these were so small as to be invisible to the naked eye and could only be detected under a binocular dissecting microscope (M6 x 20x). It will be noted that the untreated controls in the previous experiment showed no infection, whereas 63 per cent. of those in the present experiment became infected. The difference in the infection in the two controls may be attributed to a greater number of contaminating conidia in the fruit or to greater maturity; some splitting of the epidermis had occurred which was absent in the harder unripe fruit of a fortnight earlier.

7. *Viability of conidia of Sclerotina fructicola.* Conidia from copiously fructifying pure cultures of *S. fructicola* 7 days old were deposited

TABLE 3

Comparison of incidence of injection in bruised fruit of varying degrees with uninjured fruit.

Days after Bruising	Dropped from height of 3 metres		Dropped from height of 1.5 metres		Control uninjured	
	Number infected	Total	Number infected	Total	Number infected	Total
	1	1			1	1
1	6—8—10—7	31	3—3—1—1	8	1—3—4—2	10
2	4—6— 0—0	10	3—3—4—7	17	3—0—0—2	5
3	0 0 2—4	6	0 3—1 0	4	0—3—3—2	8
4	0 0 0 0	0	2 0 0 1	3	2—1—0—1	4
5	0 0 0 0	0	0 2 1 0	3	0—0—1—0	1
6	0 0 0 1	1	2 0 1 1	4	1—1—1—0	3
7	0 0 0 0	0	0 0 0 0	0	0 0 0 0	0
8	1 0 0 0	1	0 0 0 0	0	0 0 0 0	0
	Total infection	50 / 50	Total infection	39 / 50	Total infection	34 / 54
	100% infected		22% uninfected 78% infected		37% uninfected 63% infected	

The four columns of figures in each category represent the number of infected fruit in each of the four dishes.
Fruits were removed as soon as infection was noted.

on sterile filter papers Whatmans No. 4. These conidia covered papers were enclosed in sterile dry petri dishes and kept at temperatures of 2°C, 10°C, 15°C, 20°C, 25°C, 35°C and 42°C for two months. Samples were taken at intervals of one week by cutting 2 small squares of filter paper from each of the replicates and plating these out on sterile potato dextrose agar. In each case over this period the squares so tested yielded colonies of *S. fructicola* which fructified normally within 3 days.

A similar experiment using humidity chambers in place of the dry petri dishes was carried out. The humidity chambers consisted of petri dishes containing glycerol and water solutions prepared to produce relative humidities ranging from 98 per cent. to 40 per cent. After affixing the conidial covered filter papers to the inner side of the chamber, the chamber was sealed with vaseline. Chambers at each humidity level were placed at temperatures 15°C, 25°C and 35°C. Samples were taken as described above at weekly intervals over a period of six weeks.

All samples yielded colonies of *S. fructicola* which fructified normally. These results demonstrate the extremely resistant nature of these conidia, and show that conidia which may be deposited on fruit surfaces can remain viable for long periods under most conditions of temperature and humidity found in this climate.

Discussion

It has been shown that under the conditions of climate in Canberra, the airborne conidia of *S. fructicola* are carried from a few sources of primary infection early in the season, and are deposited on surrounding fruit within fairly narrow limits of distance; the number deposited decreases with increasing distance from the source of infection. This is in accord with Gregory's (1945) idea of a limited range of dispersal from the source in air-borne spores.

The deposited conidia are concealed among the hairs on the surface of the peach, accumulating gradually as the population of the pathogen is slowly built up during the early season. This gradual accumulation follows from the fact that in the field there is a low susceptibility to infection among immature fruit.

Curtis (1928) records that she found no inhibition to the growth of *S. fructicola* on peaches, whether mature or immature, once penetration had occurred. Here also it has been shown that, under laboratory conditions, there is no significant difference in proneness to infection between immature and mature fruit, so far as sub-epidermal tissues are concerned, and only a slight time-lag in infection of the whole green fruit as compared with the whole ripe fruit. It would therefore seem that one of the main limiting factors responsible for the low incidence of disease in green fruit, under natural conditions, lies in the mechanical resistance of epidermal tissues to penetration by the germ tubes. When the fruit were injured by bruising and pricking, the incidence of disease became very high even in green fruit.

Under natural conditions these injuries to the green fruit are rare, due largely to the firmness of the tissues and the absence of stress on the epidermis. In fruit approaching maturity, however, mechanical injuries are inevitable, caused by biting insects, stresses and strains of growth, or friction of close-growing fruit, etc., so that the epidermis is readily ruptured. These epidermal ruptures make entry easy for the pathogen, and thus proneness to the disease rises very considerably during ripening. As a corollary to this, the build-up of the pathogen population accelerates rapidly as the season advances, and similarly the number of conidia deposited on adjoining fruit surfaces increases greatly. It has also been shown that these conidia are very resistant, they can withstand extremes of temperature and humidity for quite long periods and remain viable.

Muller (1955) has discussed the many variable factors involved in the spread of an air-borne disease and has put these factors

together in an ideal mathematical formula

$$D = A(C.P)\frac{T}{t}$$

Where D=degree of disease infestation, after period of time T,

A=initial spare load,

C=intensity of parasites fructification,

P=probability of a single spore becoming pathogenic,

t=incubation time of fungus.

This formula demonstrates the relative importance of each of the main factors. From this it can be seen that anything which tends to increase the probability factor will also tend to increase the degree of disease incidence very greatly, whether in immature fruit where the variables are low, or in mature fruit where they are high. Environmental conditions can influence these factors. Temperature and humidity can restrict or increase directly the intensity of the parasite's fructification C, but can have also an equally telling effect on the host. After a spell of warm dry weather, a good fall of rain can produce a sudden expansion of growth in the fruit resulting in splits in the epidermis, thus increasing the probability factor just at the moment when conditions are optimal for germination and growth of the parasite. In this connection it could well be that water-logging such as Angell (1956) describes, or even different soil factors (Angell, 1955) could have such an effect on the fruit that ruptures of epidermal layers easily occur, thus increasing the P factor and so increasing disease incidence.

Wade (1956) formulated a hypothesis of latent infection to account for the isolation of *S. fructicola* from green apricots, though his investigations show only a weak and very limited expression of this. The numerous viable conidia lying on the surface of the fruit, which Wade found so difficult to get rid of, are considered here to be the real danger and the reason why an outbreak of brown rot can occur so rapidly and disastrously when owing to natural conditions and favourable environment the probability of infection becomes high. Thus instead of latent infection, latent contamination with conidia is postulated as one of the main causes of spread of the disease, so far as peaches are concerned. This could also account for the losses during transportation where bruising can easily occur, opening the door to the waiting pathogen so that fruit, healthy when packed, arrive in a rotted condition.

Gregory (1945) stressed the fact that while attention should be paid to spatial separation in protecting clean crops, more emphasis should be placed on eliminating foci of disease within a crop. The experimental results and observations recorded here can only reinforce such a conclusion. For this purpose the spraying programme for brown rot, which in the past has not been particularly successful in controlling this disease, could perhaps be guided by a forecasting system based on the number of spores deposited on fruit in certain areas. Thus it could provide more effective, because more timely, cover sprays which could lethally affect the conidia as they accumulate.

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Book Review

FIFTY YEARS OF FARM MANAGEMENT

By H. C. M. Case and D. B. Williams

(*University of Illinois Press, Urbana,* 1957)

This book is a very welcome review of the evolution of farm management in the United States during the first half of this century. It traces in considerable detail the development of farm management research and extension work together with the links between this development and the pressing farm problems and agricultural policies of the period.

In doing so it brings together the documentary evidence of innumerable research bulletins, extension publications, journal articles, committee reports and the like. In this formidable task alone the authors have performed an invaluable service to the profession.

Amongst the many aspects of farm management work discussed are cost of production surveys, model farm analysis, farm account-book record keeping, comparative studies and thermometer charts, correlation analysis of factors influencing farm incomes, enterprise costing, budgeting and input-output relationships, type of farming studies, inter-regional competition analyses, work simplification, whole-farm production functions and studies of risk and uncertainty and decision making by farmers. In addition to providing an historical review of the development of these and other techniques and fields of work, the book contains much helpful discussion of their limitations and usefulness.

If there is any major criticism of the work it is that it is sometimes insufficiently critical. The erection of signposts directing the profession along deeply crevassed deadend tracks is sometimes hailed with as much enthusiasm as the construction of super highways. In other places credit is withheld from individuals and groups for the erection of useful markers along the route on the grounds that these were long ignored by some of the traffic. Thus the work of some trail-blazing farm economists tends to be discounted because "practical" workers in the field did not immediately take more notice of it. There will inevitably be considerable dissent from the authors' assessments of just how influential some of these contributions were and differences of view on the justice done individual workers. In my view, for example, John D. Black's influence on the development of the subject receives quite inadequate recognition.

The value of the book is, however, not likely to be prejudiced by the scope for different interpretations of some of the material presented. Unfortunately much current work in farm management is totally lacking in an effective analytical framework. Often what passes for farm management work is little better than a placebo yielding nothing in the shape of useful conclusions on how to improve the organization and operation of farms. In too many places the lessons of the past are ignored and each new problem tends to be approached with a naive empiricism, altogether unmindful of the immense stock of methodological capital bequeathed to us by the pioneers of the subject. It is in helping to avoid wasteful repetition of earlier misguided efforts and in providing an inventory of tools to assist future constructive development that one of the chief values of Case and William's book is to be found. The study of the history of farm management now conveniently brought together in this text, will reward workers in all branches of the science.

J. N. LEWIS

BHC and Aldrin Spraying of Hopper Bands of the Australian Plague Locust

Chortoicetes terminifera Walk.

M. CASIMIR and E. L. JONES

BHC emulsion, BHC dispersible powder and aldrin emulsion applied as sprays at the standard concentrations of 3½ *oz,* 3 *oz and* 4 *oz of active ingredient per acre respectively, gave effective control of massed hopper bands of the Australian plague locust under field conditions. With each insecticide almost* 100 *per cent. kills were obtained within* 24 *hours of spraying, although BHC was much quicker in its action and exerted considerable control within one hour of application. Counts made indicated that escape of hoppers from the treated areas was negligible.*

An attempt to estimate population densities in massed locust swarms is described. Sample counts made showed that characteristic mixed swarms of first, second and third instar hoppers may contain from half a million to three million individuals per acre. Hoppers attained a density of almost 300 *per square foot in basking groups.*

Recommendations for the use of an insecticide against locust swarms are usually based only on qualitative estimations of the efficiency of the insecticide during testing, largely because the excitability and rapid movement of locusts in high density swarms limit the use of actual counts. Methods involving the counting of the number of locusts flushed per unit area have been used widely but, as indicated by Richards (1953), such methods tend to break down at higher locust densities and can therefore only be applied to non-swarming populations. Estimations of population densities in swarms of the desert locust, *Schistocerca gregaria* Forsk. have been made using an entirely different technique (Singh and Bhatia 1952). A wooden frame held by long wires was dropped over hoppers in a swarm and they were contained by the frame until removed for counting. Dense bands of the desert locust were found to contain huge populations, averages of 2,840 first instar hoppers and 94 fifth instar hoppers per square foot being recorded.

Estimations of the population densities of hopper bands of the Australian plague locust

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by direct counts amongst typical swarms, and insecticide treatments of these swarms, were carried out in September, 1954, at Box Ridge near the foothills of the Warrumbungle Range in New South Wales. Spray applications of the kind described below were in general use by landholders throughout this district at the time although other methods involving the use of low-volume spraying machinery or the spreading of bran baits were also widely applied.

Method

Three swarms were measured and the boundaries marked with wooden stakes. The swarms were specially selected so that they were roughly rectangular in shape and between half and one acre in size. Locust densities were estimated before and after insecticide treatment by making numerous sample counts both inside and outside the swarm areas. Counts were made in the untreated swarms in the early morning—before sunrise—when the locusts were inactive due to the cold and were least likely to be disturbed. Wire quadrats, one foot square, were lowered gently amongst the hoppers and counts made without causing the locusts to scatter. For counts outside the marked boundaries of each swarm quadrats of one square yard were used because of the low locust densities there.

The points at which counts were made were fixed arbitrarily by taking parallel transects through the swarms at intervals of ten yards and pacing a predetermined distance along each transect before lowering the quadrat to the ground directly ahead, for each count. The distance between individual counts was kept uniform for a particular swarm but varied between swarms, depending on their size. A similar procedure was adopted for taking counts of locusts outside the swarm boundaries and, here, parallel transects were taken at ten yard intervals from each boundary of the swarm under observation. The first count in each transect was made just outside the swarm boundary and further counts made at five yard intervals. The distances were measured by pacing a line at right angles to, and away from, the swarm boundary, counts

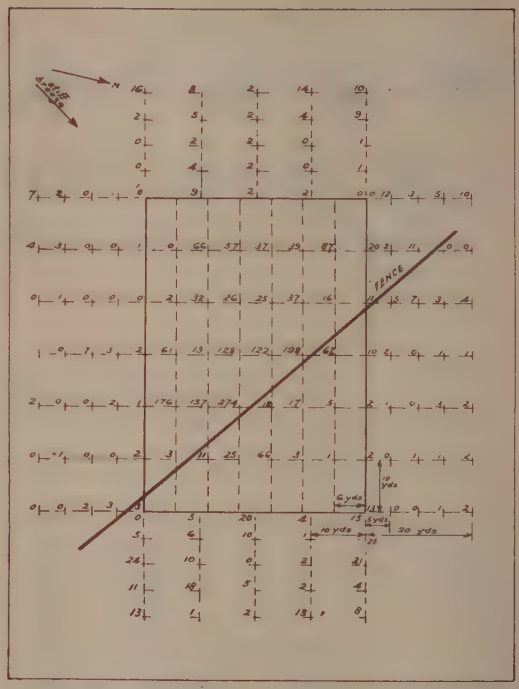

Figure 1—Diagrammatic representation of Swarm 2 and counts made inside and outside the swarm area BEFORE insecticide treatment. Figures inside the swarm boundaries represent counts of locusts made with a square foot quadrat and those outside with a square yard quadrat.

being discontinued beyond twenty yards from the nearest part of the swarm. A diagrammatic illustration of the counts made in a typical swarm is given in Figure 1.

After counting was finished the swarm under observation was immediately treated with an insecticide. Spraying was carried out with a Moffat-Virtue Roller pump operating at 200 lb pressure through two hoses each 60 feet long and fitted with Rega Double Cyclone nozzles with 1/32 inch aperture. The spraying was carried out in such a way that most of the swarm was contained within the treatment area. One spray operator worked towards the densest part of the swarm from the nearest boundary while the other operator sprayed from the side or behind the main bulk of the swarm. It was sometimes necessary partially to ring the swarm with spray before proceeding to treat the densest portions. All spraying

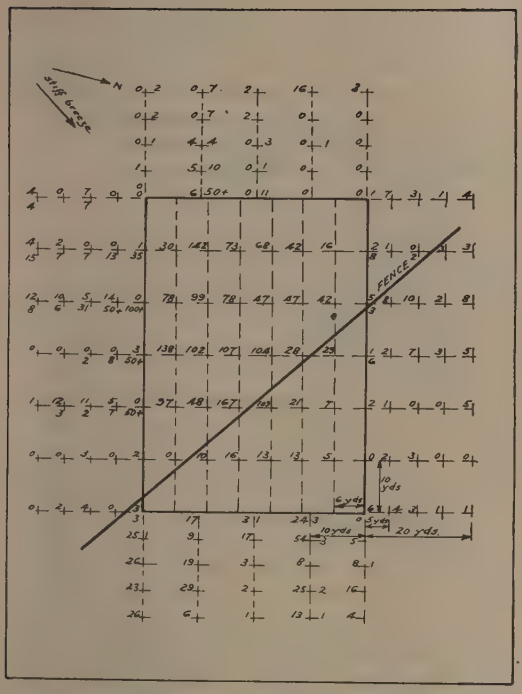

Figure 2—Diagram of Swarm 2 and counts made AFTER treatment with BHC dispersible powder. Figures inside the swarm boundaries represent counts of dead locusts made with a square foot quadrat and those outside with a square yard quadrat. In the latter, two sets of figures are given representing counts of live hoppers and to the right of or below these, counts of dead locusts where they were observed.

was confined to the areas defined by the staked boundaries.

Counts of dead and surviving hoppers were made approximately 24 hours after spraying. The same method of sampling was used as for counts carried out before treatment (Figure 2).

Results

Swarm 1

The swarm was approximately one acre in extent and consisted of first, second and third instar hoppers. First counts were made between 6 a.m. and 8 a.m. on September 26, and treatment was carried out between 9 a.m. and 1 p.m. in hot weather with a light variable breeze. The insecticide used was 7 per cent. BHC emulsifiable concentrate diluted at the rate of 2½ pints to 80 gallons of water and applied over one acre—equivalent to 3½ oz of gamma isomer BHC per acre.

Final locust counts were made between 4 and 6 a.m. the following day.

The swarm was located on ground bare except for a faint green tinge of pasture growth and a few clumps of saffron thistle.

Hoppers inside the treated area were affected by the spray almost immediately, signs of paralysis being evident within ten minutes of treatment and two to three hours later very few live hoppers remained and there appeared to be little or no escape from the treated area. There were no survivors in the treated area the following day. Results are summarised in Table 1.

Swarm 2

The swarm was half an acre in extent and consisted of first, second and third instar hoppers. First counts were made between 6 a.m. and 8 a.m. on September 27, and treatment was carried out between 9 a.m. and 1 p.m. on the same day. One and a half pounds of 50 per cent. BHC dispersible powder were applied in 40 gallons of water over half an acre, equivalent to 3 oz gamma isomer BHC per acre.

Final counts were made between 4 a.m. and 6 a.m. next day.

Ground cover was similar to that described for Swarm 1 and the weather was warm during spraying, with a strong breeze.

The reaction to the BHC dispersible powder was not immediate as in the case of the emulsion form of BHC and three hours after spraying there were still numbers of survivors, although many of these were then obxiously affected by the insecticide. No live hoppers remained in the treated area the following morning nor was there any noticeable escape of locusts into surrounding untreated areas. Results are summarised in Table 1.

Swarm 3

The swarm was half an acre in extent and was similar to Swarm 2 except that the locust

TABLE 1.

Average locust counts per square foot.

	Swarm 1 BHC emulsion	Swarm 2 BHC powder	Swarm 3 Aldrin emulsion
Counts inside swarm area			
Live hoppers before treatment	30.9 ± 7.7	58.5 ± 11.8	11.7 ± 3.6
Survivors after treatment	0	0	0
Dead hoppers after treatment	36.6 ± 5.4	58.9 ± 8.3	20.2 ± 2.8
Highest number recorded (before treatment)	294	274	226
Number of samples	58	30	66
Counts outside swarm area			
Live hoppers before treatment	0.05 ± 0.01	0.48 ± 0.06	0.31 ± 0.06
Live hoppers after treatment	0.13 ± 0.02	0.57 ± 0.08	0.48 ± 0.08
Number of samples (square yard)	140	120	120

density was much lower and twice as many counts were taken in an effort to obtain a more accurate estimate of the population. First counts were made between 6 and 8 a.m. on 29th September and treatment was carried out between 9 a.m. and 1 p.m. the same day. One quarter of a pint of 40 per cent. aldrin emulsifiable concentrate in 40 gallons of water was applied to the half acre swarm, equivalent to 4 oz aldrin per acre.

No immediate effect was obtained with aldrin, and even several hours after spraying few hoppers were dead although large numbers then appeared to be affected by the insecticide. Although exhibiting the usual muscular spasms associated with chlorinated hydrocarbon poisoning, the locusts were still able to hop and move around. However, the following morning there were no survivors in the treated area. Results are summarised in Table 1.

Discussion

Clark (1949) has described a daily behaviour regime in swarm hoppers of *Chortoicetes terminifera*. The locusts form basking groups in the early morning until temperature has increased sufficiently for marching to begin. As marching slackens off late in the day basking groups reform. In this investigation counts could not be made amongst marching bands and were thus restricted to the early morning period when the hoppers were least active. At this time of day the locusts are concentrated into a number of dense basking groups as along the fence line in Figure 3. As the temperature rose and the hoppers were disturbed by spraying operations they tended to scatter evenly over the area. The greater variability of the sample counts made of living

Figure 3—Part of hopper swarm at Box Ridge showing basking groups near water trough and on wooden post. The terrain is typical of the area.

hoppers before spraying is indicated in Table 1 and this was almost certainly due to the marked grouping of a major proportion of the hoppers into a relatively small fraction of the area under inspection. The after-spray counts would probably provide a better measure of the swarm populations, even though some locusts might have escaped from the treatment areas. However, the original counts do indicate the extremely dense groups which are formed in an average swarm. Densities approaching 300 hoppers per square foot were recorded.

Considerable numbers of insecticide-affected hoppers moved a few yards out of the sprayed area before dying (Figure 2) but the escape of surviving locusts from the various swarm areas was not great (Table 1). In fact the differences in the means of counts made outside the boundaries of the treatment areas before and after spraying are not significant at the 0.02 level and the slight increases recorded were probably due to chance alone. Thus survival inside the swarm area in each treatment was nil (Table 1) and escape from the treatment areas was negligible, indicating that both insecticides, BHC in the emulsion and powder form and aldrin, were extremely efficient against first to third instar hoppers at the standard concentrations used, and that the three sprays killed all hoppers that were hit, giving 100 per cent. control under field conditions.

In view of the efficiency of all three treatments the after spray counts made inside the swarm areas can be used to give an estimate of total numbers of each swarm, particularly as these figures give less variable estimates than the before spray counts. The basking groups of hoppers so evident during counting of the untreated swarms had been to some extent dispersed and the reduced standard errors of the after spray mean counts reflect the improved efficiency of the sampling although the confidence limits are still quite wide. For example, the calculated figure with standard error from Table 1 for Swarm 1 would be approximately 1.6 $\pm$ 0.2 million individuals over an area of one acre. Similarly, for Swarm 2, the figure would be 1.3 $\pm$ 0.2 million hoppers over an area of half an acre, and for Swarm 3, 450,000 $\pm$ 60,000 hoppers over half an acre. Expressed as a fiducial probability of 0.95 the real population of Swarm 1 was somewhere within the limits 1.1-2.1 million, Swarm 2 within 0.9-1.6 million and Swarm 3 within 0.2-0.6 million locusts.

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Amnemus quadrituberculatus (Boh.), A Weevil Pest of Clover Pastures on the North Coast of N.S.W.

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The importance of the weevil Amnemus quadrituberculatus (Boh.) as a potential pest of clovers in coastal New South Wales was not realised until attempts were made to establish subterranean clover (Trifolium subterraneum L.) by sod-seeding into the grass dominant pastures of the Richmond River.

Surveys showed that the insect is widespread in New South Wales from the Tweed to the Manning River both in natural clover pastures and in those established by sod-seeding, over-seeding, or seeded into clean seed beds. It occurs in a wide range of soils. Field observations have indicated a close association between the weevil and white clover and this species may be the natural host plant of the insect.

The adult weevil is a foliage feeder, apparently being restricted to legumes, and causes little damage. The main injury is caused by the larvae which are root feeders on legumes in the autumn and winter months.

Laboratory techniques for studies of the life history, and other aspects of the biology of the insect, are described.

Satisfactory control measures have not been determined. Preliminary field trials indicate that surface treatment with an insecticide incorporated in fertilizer at a time when adult weevils are abundant (January) may prove effective.

A University of Sydney-Department of Agriculture project to provide a legume in the nitrogen deficient grass pastures of the Richmond River District of N.S.W., has been brought to a virtual standstill by the depredations of the weevil, *Amnemus quadrituberculatus* (Boh.). This insect had attracted very little attention previously and was not recognised as a pest of considerable importance on clovers and other legumes until 1956. During the winter of 1956 sod-seeded subterranean

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clover (*Trifolium subterranean* L.) pastures which had shown great potential up to that time were nearly all destroyed by *Amnemus*.

This paper outlines the *Amnemus* investigational programme initiated at Wollongbar Experiment Farm (Richmond River) in 1957 and the progress that has been made in the last twelve months.

Synonymy

The insect was originally described as a member of the genus *Leptops* by Schoenherr (1834), its range being given as Australia: it has not since been recorded elsewhere. The genus *Amnemus* was erected by Marshall (1952), who commented "*Amnemus* includes *Leptops quadrituberculatus* Boh. (= *squamosus* Lea. syn. n) which is the genotype, *superciliaris* Pascoe and a third undescribed species".

Distribution

There are few records in the literature or in entomological collections concerning the distribution of *Amnemus*. It appears to have been collected only in coastal districts of N.S.W. and Queensland—from the Illawarra district (South Coast, N.S.W.) to Rockhampton. A single specimen collected at Doyles Creek, Hunter River, provides the most westerly record of the insect, although larvae have recently been taken from clover pastures at Dorrigo and in the Tabulam district.

Except for a doubtful record of adults feeding on the foliage of French beans at Austral Eden, Macleay River, 26/2/41, host records were lacking until 1953. In August 1953, larvae were taken from red clover roots at Kyogle and Murwillumbah. In June 1954, larvae were recorded doing extensive root damage to subterranean clover in the Old Bonalbo District.

Following this initial report of damage on subterranean clover larvae were collected in numerous localities in the Richmond River District in 1955 and 1956, and, in the latter year, the seriousness of the insect was realised when practically all subterranean clover stands in that district were destroyed.

During 1957, distribution surveys were carried out on the coast of N.S.W. These showed that *Amnemus* is widespread in coastal districts from the Tweed to the Manning River, Burrell Creek on the Manning being the approximate location of the southernmost collection point. In some localities larval populations were extremely dense and damage to native white, ladino, red, and subterranean, clovers was very severe. The worst areas of infestation, apart from the Richmond River, appeared to be the Coffs Harbour, Bellingen, Nambucca, and Macleay River districts. While there are scanty records of the occurrence of *Amnemus* on the Hunter and Williams Rivers, and even further south, neither *Amnemus* nor clover damage was recorded in these districts in these surveys. The Manning River may therefore be regarded, from an economic point of view, as the southern limit of the species.

A most interesting finding of these surveys was that *Amnemus* occurs both in hillside and river flat pastures, in many different soil types, and in all classes of pasture, viz. natural, sown in clean seed-beds, over-seeded and sod-seeded. Infestations however occurred only in freely drained soils Although the weevils were very numerous in both irrigated pastures and in soils subject to quick flooding they were not recorded in any low-lying flood plain pastures where water may lie for prolonged periods.

Description

The adult weevils are 7 to 12 mm long. The females are usually longer and broader than the males. Their colour varies according to the soil type in which they are found. In the chocolate basalt soils of the Kyogle district their body colour is frequently deep grey ranging to black, while in the red soil areas at Wollongbar it is brick red. Fawn, ranging to brick red, is the most common colour. They have the typical curved snout, or rostrum, of the family but are readily distinguishable from most other weevils by four pronounced spines on the fused elytra.

The larvae are white legless grubs ranging in length from 1.6 mm in the first instar to 9 mm in the final instar. The head is large, honey-coloured, and has two prominent white stripes on the frons.

Figure 1—Lateral view of seventh instar larva of A. quadritubereulatus. x 8.

The eggs are cigar-shaped and approximately 1.5 mm long and 0.5 mm wide. When laid the eggs are white but after a few days their colour changes to a pale yellow.

Damage

The adults feed only on the above-ground portions of legumes and do little damage. They feed at the edges of the leaves, standing astride the edge and making typical round cuts in them. They frequently chew through the petioles of clover plants, dropping the severed leaflets to the ground.

Larval feeding causes the most serious damage done by *Amnemus*. Typically it consists of either a gouging out or a severing of the clover root about one half inch below ground level. The depth at which feeding takes place appears to depend on the moisture content of the soil. Fibrous roots are usually produced above the injury and these enable damaged plants to survive in a weakened condition if the top soil is moist. If the surface soil dries out, the substituted root system is inadequate and affected plants wilt and die. Grazing stock hasten the death of injured plants by breaking them off at the point where the larvae have fed, and such plants are commonly seen scattered through the pasture.

The effects of *Amnemus* feeding and injury are much more apparent where clovers with a well defined tap root are grown, e.g. subterranean clover (*Trifolium subterraneum* L.), crimson clover (*T. incarnatum* L.), and red clover (*T. pratense* L.), because of their dependence on the main tap root. Clover species such as white clover (*T. repens* L.) which have poorly defined tap roots or a stoloniferous habit, are much better able to withstand *Amnemus* feeding. Damage in such pastures is difficult to see and is often not recognised. Nevertheless a careful examination of the roots reveals the same sort of

Figure 2—Dorsal view of adult of A. quadritubereulatus. x 8.

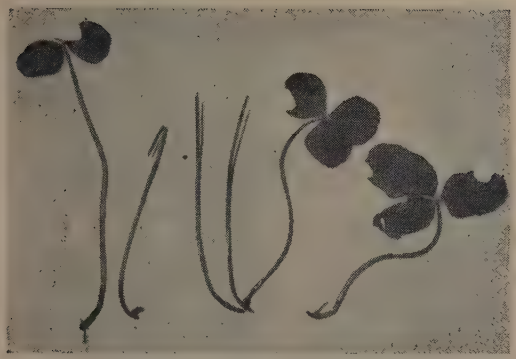

Figure 3—Damage by adult weevil to leaves and petioles of Clare subterranean clover.

damage, and heavily infested stands, while appearing green and healthy, usually make little growth even under adequate moisture and nutrient conditions.

Laboratory Breeding Techniques

Emphasis in laboratory studies was placed on the working out of the life history of *Amnemus,* and on the development of suitable breeding techniques.

A plentiful supply of adults was collected from a summer legume nursery at Wollongbar Experiment Farm in March. To obtain records of oviposition pairs were enclosed in lamp glasses set in four inch diameter petri dishes, and covered with gauze. The adults were fed on white or subterranean clover, one or two rooted stems being placed in a small quantity of dampened soil in the petri dishes each day. These small pieces of clover plants provided food for the insects, and also egg-laying sites. Daily egg counts were obtained by removing the stems, by splitting the petioles down the centres with a fine needle, and counting the eggs within. The food was then renewed.

Figure 4.—Typical larval damage to Clare subterranean clover. Note gouging and severing of the tap root.

Eleven pairs of adults were used to provide information on fecundity, feeding habits, copulation, oviposition and longevity.

Larvae were obtained from eggs hatched in the laboratory. A selection of larvae, from eggs laid in each of the autumn and winter months, were reared singly in 2 in. x 1 in. glass tubes to determine the number of larval instars and the length of the larval and pupal periods. They were fed on subterranean clover seedlings growing in about one inch of slightly dampened soil. The food was replaced when necessary. Head capsule measurements were made every few days to determine the number of larval instars.

From an original selection of 45 first instar larvae, 35 were reared successfully to the adult stage and the majority of the others survived long enough to provide useful information.

The rest of the larvae reared in the laboratory were placed in glazed earthenware pots containing well grown subterranean clover plants. They were used for general observations of larval feeding and of the length of the larval and pupal periods. In later instars many were removed for studies of host range.

In addition to laboratory studies, which were conducted at room temperature, field observations were maintained throughout the year of the occurrence and habits of the various stages of the insect.

Life History

Adults—

Little is known of adult behaviour. The weevils are inconspicuous in pastures, even when present in large numbers. In common with many other weevils, they drop to the ground when disturbed and remain motionless. They are wingless but are capable of rapid movement and may thus spread fairly quickly.

Adults are present in the field from spring until early winter. November to March is probably the period of greatest activity. Twelve pairs of laboratory held adults, collected from the summer legume nursery in April, survived into August and six pairs into September, but none were found in the field after June.

The adults begin feeding as soon as they emerge from the earthen pupal cells in the soil and continue to do so actively throughout the warm summer and autumn months. In winter, very little feeding takes place. Adults have been found feeding on a wide variety of legumes including *Desmodium* sp., *Dolichos lablab* L., *Glycine javanica* L., *G. Max.* (L.) Merrill, *Phaseolus bracteatus* Nees & Marty, *Crotalaria* sp., *Trifolium subterraneum, T. pratense, T. repens* and *T. hybridum* L. The summer legume *Desmodium sandwichense* E. Mey. is a particularly favoured adult host plant.

After emergence, some weeks elapse before sexual maturity is reached and egg laying begins. Copulation occurs repeatedly throughout the oviposition period.

Eggs—

Detailed laboratory work began in late March and it is highly probable that at least 2 months of the egg laying period had passed before egg counts were started. However, daily counts from April 1, give some indication of the fecundity of *Amnemus*.

Individuals laid up to 40 eggs per day. The total number of eggs laid by eleven females in the five months period, April to September, ranged from 650 to 1,100 each and approximately 40 per cent. were laid in April.

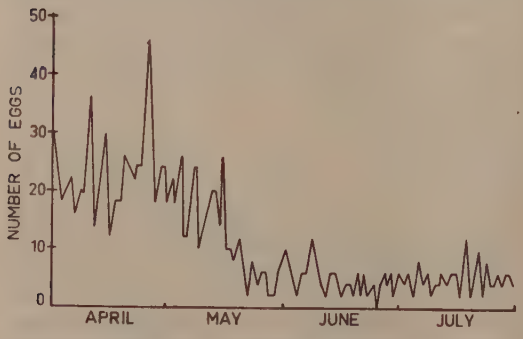

Figure 5—Daily egg production in months of April-July. Mean number of eggs laid per day by 11 females.

Figure 6—Monthly egg production, April-July. Mean number of eggs laid per month by 11 females.

It was evident that oviposition had passed its peak in April so *Amnemus* would probably lay 1,000 to 2,000 eggs under laboratory conditions.

Field egg-laying is believed to take place on a much smaller scale. Limited observations indicate that under natural field conditions oviposition is only about one quarter of that recorded in the laboratory.

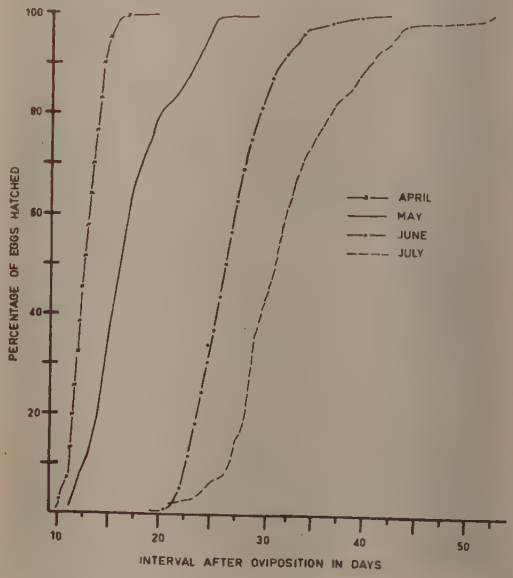

Figure 7—Cumulative curve showing percentage egg hatching per day in months of April-July.

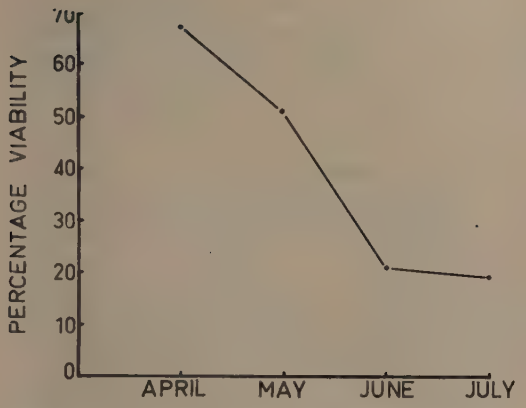

Figure 8—Viability of eggs per month. Eggs produced by 15 females, April-July.

The eggs are laid in the central hollows of the petioles of clover plants. They are generally deposited in the lower portion of the petiole where the hollow is well defined. Groups of 3 or 4 along the length of the hollow are common but chains of up to 14 have been found.

Oviposition is known to take place in *Trifolium pratense*, *T. repens* (white and ladino clovers), *T. hybridum* and *T. subterraneum* which represent only a few of the host plants on which adult *Amnemus* have been found feeding. It is possible that egg laying takes place only in those species with hollowed petioles or stems.

The incubation period of laboratory-held eggs ranged from 10 to 51 days. In April incubation did not exceed 17 days, and 75 per cent. of the eggs hatched in 12 to 14 days. In June and July the incubation period was considerably longer, and in the latter month approximately 70 per cent. of the eggs hatched in 25 to 35 days.

April laid eggs were up to 92 per cent. viable (average 68 per cent.), but with the onset of cooler weather, and possibly also because of a natural reduction in fertility, viability declined considerably.

Larvae—

Larvae may be found in the soil from March until November or December. Throughout this period larvae of all stages of development are seen, but in August and succeeding months, increasing numbers of advanced larvae, prepupae and pupae are found. The majority of larvae pass through seven instars over a period of 12 to 16 weeks after which they enter a prepupal stage for a period varying from 2 to 9 weeks. In the final larval instar an earthen cell is constructed and both prepupal and pupal stages are passed in this.

The method of entry of the larvae into the soil has not been observed but apparently on hatching they eat their way through the clover petioles and drop to the soil. On reaching the soil they immediately begin feeding on the clover roots, a preference being shown for tap roots or stout stolons. The depth at which feeding occurs depends on the soil moisture level, and larvae have been found at depths ranging from ground level to nine inches. Moisture is a critical factor in their development, and they are sensitive both to excessive and insufficient soil moisture, but are better able to tolerate dry conditions than wet. They feed throughout their developmental period, but damage to plants is most pronounced in autumn and early winter.

In the glass house, larvae have been found to feed on *Trifolium alexandrinum* L. (berseem clover), Clare, Yarloop, Bacchus Marsh, and Dwalganup strains of *T. subterraneum* and *Vigna sinesis* Endl. (cowpea), but a wide range of plants remains to be tested. In the field, damage has been recorded on subterranean, red, white and ladino clovers and vetches (*Vicia* sp.).

Pupae—

The pupae are found scattered in the soil in earthen cells under the clover plants, but not in close association with the roots. They are most numerous in the field in spring, but in the laboratory have been obtained in August. The pupal stage lasts 18 to 26 days with glasshouse reared material and the newly emerged adults remain several days in the earthen cells until they are fully hardened. Under natural conditions the pupal period may be longer and hatching appears to be greatly influenced by moisture.

Significance of White Clover

In the surveys mentioned a close association between *Amnemus* and native white clover was

evident. In all localities where high numbers of *Amnemus* were discovered, native white clover pastures were heavily infested.

In natural pastures throughout the Lismore district white clover was found to be favoured for egg laying, and in autumn it was difficult to collect material which was free of *Amnemus* eggs. Subterranean clover sodseeded into the natural pastures of all the different soil types of the Richmond River has gradually been wiped out, suggesting that an existing *Amnemus* population gradually builds up when provided with a favourable habitat.

These facts all lend weight to the theory that white clover is the natural host plant of this insect. Over the years white clover, which was once abundant, has gradually disappeared from the hill pastures of the Far North Coast, and the possibility of *Amnemus* being responsible, at least in part, for its disappearance cannot be overlooked.

Control

At the present time no satisfactory measure for controlling *Amnemus* is known. As the larvae are crown or underground root feeders, any control measure might best be timed to coincide with adult activity and egg laying so as to prevent the entry of larvae into the soil. From our knowledge of the life history of the insect, larvae may be expected to attack clover roots in the summer and autumn germination period and throughout the winter growth period, so that control measures aimed at killing the adults and preventing egg laying would be required at some time in summer.

Control by cultural practices appears to have little application against this insect in sod-seeded pastures, but may be of some use with clovers sown in clean seed beds, or overseeded. The principal purpose of sod-seeding legumes is to disturb the pasture sward as little as possible and limit erosion; any cultural practice such as renovation, which involves opening up the soil, is not desirable. Where there is no erosion hazard, and either of the other two methods of sowing can be used, judicious renovation may be of some value in early autumn in exposing young larvae or destroying eggs. Well-timed mowing or grazing might similarly have some value in all classes of pasture, chiefly to reduce egg populations in the summer and autumn period. Otherwise, cultural practices by themselves appear to offer little prospect of controlling this insect.

Control Experiments

Preliminary experiments were carried out in the Wollongbar district to determine the effectiveness of a number of insecticides against *Amnemus* in established clover stands and in pastures being seeded down with subterranean clover. Time and method of application of insecticides were considered concurrently.

Dust formulations of insecticides were used in all experiments and were applied in conjunction with fertilizer. In the trials in established pastures the insecticides were hand broadcast to simulate surface application with a fertilizer spreader. In the trial in newly sown pastures the insecticides were applied at sowing time through the sod-seeder.

Established Clover Stands

Efficacy of insecticides.—No results were obtained from this trial. It failed as a result of severe drought, a clover rust epidemic and *Amnemus* damage.

The experimental site was a second year stand of Clare strain subterranean clover sodseeded into a paspalum pasture. Insecticides under test and acreage doses were:— Dieldrin —2 lb, Aldrin—4 lb, Chlordane—8 lb, DDT—10 lb, BHC—1.5 lb gamma isomer.

Optimum time for application of insecticide.—This experiment was carried out in two different stands of clover, viz. a third year stand of Clare subterranean clover sod-seeded into a natural carpet grass/paspalum pasture, and a stand of native white clover in a mixed paspalum/kikuyu grass pasture. Insecticide was applied in January, March and June. The three treatments, involving the use of a standard insecticide, Dieldrin, at the rate of 2 lb per acre, were replicated six times in twenty-four randomly selected plots—including controls.

In the subterranean clover experiment the effectiveness of treatments was assessed on larval numbers obtained by soil sampling and

TABLE 1.

Number of larvae and percentage of root damage in subterranean clover and white clover plots treated with Dieldrin at various times.

		Treatment	Larvae Total/ Treatment	Larvae Mean No./ Plot	Damaged Roots (%/Treatment)
Subterranean Clover	January	(2 lb Dieldrin /acre)	12	2.0	18.1
	March	(„)	15	2.5	25.4
	June	(„)	34	5.7	32.5
	Control	(No treatment)	22	3.7	41.3
		Differ. for signif. at 5% level.		2.5	No signif. diff.
White Clover	January	(2 lb Dieldrin /acre)	9	1.5	
	March	(„)	39	6.5	
	June	(„)	70	11.7	
	Control	(No treatment)	47	7.8	
		Differ. for signif. at 5% level.		5.6	

by numbers of *Amnemus* damaged plants. (Table 1.) In the white clover experiment, results were assessed by larval sampling only, as the stoloniferous growth habit of white clover made root injury counts too difficult to obtain (Table 1). All sampling was carried out in August or September when larvae were well developed.

Soil sampling of larvae was done by taking 9 in. x 9 in. x 4 in. randomly selected soil samples and separating out the larvae. Five samples per plot were taken from the subterranean clover experimental area and ten per plot from the white clover experiment. Damage counts were made by taking ten 9 in. x 9 in. quadrats at random in each plot and classifying the clover roots as either *Amnemus* injured or uninjured after digging.

The white clover trial revealed a marked superiority for treatment in January. From field and laboratory experience January corresponds closely to the period of peak adult activity. An effective insecticide applied at that time might be expected to control both adults and hatching larvae and also limit egg-laying. This presupposes depositing the insecticide on the soil surface where adults and larvae would contact it. The insecticide —fertilizer mixture appeared to be promising in that respect.

No explanation can be offered for the failure to obtain a comparable result in the subterranean clover trial. However hand broadcasting was certainly not conducive to uniform plot treatment as considerable variations were recorded in larval numbers and plant damage in most plots.

Newly Sod-seeded Subterranean Clover Stands Efficacy of insecticides.—A grass paddock almost completely devoid of native clovers was sod-seeded in March 1957 with Clare subterranean clover and the following insecticides, mixed with neutralised superphosphate, were applied at the dosage rates per acre indicated:—

Dieldrin 2 lb, Aldrin 4 lb, Chlordane 8 lb, DDT 10 lb, BHC 1.5 lb gamma isomer.

In all, seven treatments were used. They included two controls (no insecticidal treatment), one with inoculated seed and the other with uninoculated seed. In addition to testing the efficacy of insecticides applied with the sod-seeder, the trial was used to study the effects of the insecticides on root nodule bacteria—*Rhizobia.* The results of this phase

TABLE 2.

Establishment of subterranean clover plants on sod seeded plots treated with various insecticides.

Treatment	Mean No. Clover plants/plot (40ft x 2ft. samples/plot)
Unin. control	91
Inoc. „	101
BHC 1.5 lbs gamma isomer / acre	95
Dieldrin 2 lbs act. ingr. / acre	148
Aldrin 4 lbs act. ingr. / acre	158
DDT 10 lbs act. ingr. / acre	159
Chlordane 8 lbs act. ingr. / acre	150
Diff. for signif. at 5% level	30.4
„ „ „ „ 1% „	41

of the experiment are published elsewhere in this Journal.

The seven treatments were replicated six times in randomised blocks, each plot having dimensions of 40 ft. x 13 ft. In June, when germination was complete, an establishment count of clover plants was made. *Amnemus* damage was neither anticipated nor observed in this first year stand since the area was lacking in white clover, the accepted natural host of *Amnemus*. It is expected that if any of the insecticides is to prove effective a result cannot be anticipated until the second crop year. The establishment count in which 40 random counts were made per plot with a 24 in. linear quadrat, showed that dieldrin, aldrin, chlordane, and DDT were valuable in protecting the young clover seedlings from attacks by insects, notably crickets, which congregate in the shallow furrows made by the tynes of the sod-seeder and nip off the germinating plants. (Table 2).

Acknowledgements

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Technical Notes

Effect of Insecticides on Sod Sown Sub Clovers

Efforts to introduce clover, in particular *Trifolium subterraneum* L. (subterranean clover), on the Far North Coast of N.S.W. have been restricted by severe infestations of pasture insects. This applies particularly to sod-seeded subterranean clover where the seed is sown direct into the pasture, and thus into a natural environment for insects. The plants are first attacked at the seedling stage when pests such as caterpillars, crickets, and slugs feed along the sod-seeder furrows and eat off the cotyledons before the clover has gained its true leaves. The more mature plants are attacked by a weevil *Amnemus quadrituberculatus* (Boh.) the larvae of which live in the soil and chew off or gouge out the tap roots of the clover plants about one half inch below the ground. *Amnemus* presents the greatest problem in insect control.

In attempts to develop suitable control measures against these insects, particularly *Amnemus,* the method of including an insecticide with the prescribed fertilizer mixture at sowing time was considered. Under sod-seeding conditions the inoculated clover seed would lie in very close contact with the fertilizer-insecticide mixture. Consequently the root nodule bacteria could very easily be affected by an insecticide having bactericidal properties. As inoculation of clover seed with a rhizobial culture is essential for obtaining successful establishment under Far North Coast conditions, it is obviously important that insecticides for the control of *Amnemus* and other pasture insects should be screened for any effects they may have on the viability of the root nodule bacteria. This paper reports on the effect of several insecticides on the nodulation of sod-sown Clare subterranean clover.

Method

The experiment was conducted during 1957 at Messrs. W. & G. M. Bryant's property, Wollongbar, on a paspalum-carpet grass dominant paddock where there was no evidence of any native white clover (*Trifolium repens* L.).

Six replications of the following treatments were sown in randomised plots with the University prototype sod-seeder (Breakwell and Jenkins 1953):—

A. Inoculated control.
B. A. + Aldrin 4 lb active ingredient per acre.
C. A. + Dieldrin 2 lb active ingredient per acre.
D. A. + Chlordane 8 lb active ingredient per acre.
E. A. + DDT 10 lb active ingredient per acre.
F. A. + BHC 1.5 lbs gamma isomer per acre.
G. Uninoculated control.

All the insecticides were mixed with the special-mix fertilizer recommended for sod-seeding in the red soils of the Big Scrub area of the Richmond River. This is a mixture of 2 cwt Mo-superphosphate, 2 cwt dolomite, and 10 lb sodium nitrate, sown at 4 cwt per acre. The Clare subterranean clover was sown at the rate of 10 lb per acre. The seed was inoculated with a mixture of agar rhizobial cultures, at the rate of one 4 oz bottle of agar culture per 12 lb of seed, and a commercial peat culture at the rate of one packet per 60 lb of seed. Strains were NA30 and TA1.

The plots were sown on March 21, into a moist soil but very little rain fell during the following six weeks. The plots were sampled on June 3, and nodulation assessed. Forty random throws with a two ft. rule were made per plot, the plant closest to the centre of the rule being lifted each time. The plants were classified as carrying either *crown nodules,* if they had one or more effective nodules on the tap root, *other effective nodules,* if they had effective nodules on any part of the root system, or *nil,* if they did not carry any effective nodules. After nodulation had been

TABLE 1.

Percentage nodulation, and weight of dry matter.

Treatment	% Nodulation Crown	% Nodulation Effective	Dry Matter Top Weight Mean per plot (gms)
A. Inocul. control	87.1	96.6	5.67
B. A + Aldrin	76.6	90.1	3.69
C. A + Dieldrin	71.2	89.1	4.67
D. A + Chlordane	69.1	87.1	5.02
E. A + DDT	60.4	79.1	3.26
F. A + BHC	18.3	28.6	1.62
G. Uninocul. control.	7.9	18.5	1.77
Min. significant difference P = 0.05	10.79	13.69	1.55

evaluated the plants were cut off at the crowns, bulked, and the dry matter yields of the tops taken.

Results

The plants established very well and treatment differences were apparent by observation soon after establishment. Nodulation and yield results are given in Table 1.

The low crown nodulation figure for treatment G (uninoculated control) indicated that the native population of rhizobia was very low and that any effective nodules formed were probably introduced strains. The insecticides had a graded effect on crown nodulation in the order aldrin, dieldrin, chlordane, DDT and BHC, the latter having a drastic inhibitory effect. Although aldrin did not significantly reduce crown nodulation, its effect was not markedly different from the other insecticides, excluding BHC.

BHC greatly reduced effective nodulation, indeed almost to the level of the uninoculated control. DDT had some reducing effect but this was not nearly so serious as that due to BHC. Aldrin, dieldrin and chlordane, although affecting crown nodulation, did not significantly reduce effective nodulation.

Some correlation was evident between nodulation and yield, particularly in the BHC and DDT treated plots where both poor nodulation and low yields were obtained. In view of the relatively high nodulation figures for aldrin, the low yield figure must be attributed to some cause other than nodulation.

Discussion

All the insecticides were applied at very heavy acreage dosage rates and from a practical point of view, unless there was a marked effect on nodulation, it was considered that they could be quite safely used. In this regard the results showed that BHC and possibly DDT should not be added to the sowing mixture if the inoculated seed is to be sown in close contact with the fertilizer and insecticide. Aldrin, dieldrin and chlordane do not appear to have a drastic effect on nodulation, and further work with them for insect control is indicated.

Conclusions

The effect on nodulation of several insecticides mixed with fertilizer, and sod-sown in direct contact with inoculated subterranean clover (*Trifolium subterranean*) seed is described. It is concluded that the effects of aldrin, dieldrin and chlordane were relatively slight, being chiefly reflected in a reduction of crown nodulation. DDT, and particularly BHC, were more drastic in their effects, and their use with inoculated seed is not recommended.

Acknowledgements

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Resistance to Dieldrin and Aldrin in *Lucilia Cuprina* Wiet

Resistance to dieldrin in both female flies and prepupae of a field strain of *Lucilia cuprina* has already been mentioned (Shanahan 1958). Results from further work on this strain, which was established from larvae obtained from active strikes on sheep on a property in central western New South Wales, are given herein.

Aldrin mainly, but some dieldrin, had been used on this property for three years prior to the complaint that unsatisfactory prevention of fly strike in sheep was being obtained by these insecticides.

Additional tests involving the topical application of dieldrin liquids to female flies (Kerr 1954) have established that negligible mortality occurs at rates below 0.25 microgram of dieldrin per fly. Mortalities between 50 and 65 per cent. are obtained with dosage rates between 0.5 and 5 micrograms of dieldrin per female fly. Dosage rates in excess of 5 micrograms per fly give 80 to 100 per cent. mortality.

Since the susceptible strain of flies have an LD50 in the order of 0.025 microgram of dieldrin per fly, the field strain has a resistance to this insecticide of not less than 100 times normal. The dosage response data indicate that the field strain is heterogeneous towards dieldrin.

Further tests with prepupae have revealed that those from the field strain are able to tolerate immersion in 2 per cent. dieldrin emulsion with at least 75 per cent. hatch of flies. No flies emerged from prepupae of the susceptible strain when immersed in 0.05 per cent. dieldrin emulsion.

Resistance to dieldrin in young larvae was also shown by implanting larvae from both resistant and susceptible flies on to four sheep treated, one week previously, with 0.025, 0.05, 0.1 and 0.2 per cent. dieldrin emulsion. The larvae from the resistant flies established strikes, whilst a complete mortality of susceptible larvae resulted.

Female flies of the field strain also have resistance to aldrin in the order of 50 times normal but the strain also exhibits heterogeneity towards this insecticide. A dosage

of 1.25 micrograms of aldrin per female fly is close to the LD50 for the field strain.

Initial tests with DDT and gamma BHC against adult female flies have shown that there is no pronounced cross tolerance to these insecticides. The strain is not resistant to diazinon.

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Clover Seed Pelleted with Bentonite and Organic Material as an Aid to Inoculation with Nodule Bacteria

In certain areas of Australia difficulty is encountered in establishing pasture legumes on soils of low fertility. This has been traced in many instances to failure of the commonly used inoculation procedures in which appropriate nodule bacteria are placed before sowing, directly on the seed surface, either from an agar culture or by dusting the seed with a partially dried carrier such as powdered peat.

In some areas inoculation failure has been traced to soil acidity which prevents multiplication of the inoculum in the rhizosphere of the developing seedling. This effect of soil acidity can be overcome by coating the seed with calcium carbonate (Loneragan *et al,* 1955).

In certain other soils of pH 6-7, failure of inoculation has been shown to be associated with microbiological antagonism in the rhizosphere of the seedlings resulting in severe limitation of the spread of nodule bacteria from the inoculum on the seed (Hely, Bergersen and Brockwell, 1957). It is against this latter effect that the work to be described in this preliminary report was aimed.

Hely, Bergersen and Brockwell (1957) tried a number of ameliorative measures and one of the most effective was an increase of the numbers of bacteria in the inoculum from 10^4 per seed to about 10^7 per seed. This higher level is quite impossible from a practical standpoint because of the cost and difficulty of application. Consequently a method was sought which would enable this increase in inoculation level to take place fairly rapidly in nutrient material around the seed during germination.

Experimental

Subterranean clover seed was pelleted by spraying with neutralized 15 per cent. (W/V) gum arabic in water followed by agitation in a mixture of dry Wyoming bentonite and one of a number of organic materials which were found, by the use of their water extracts as culture media, to be capable of supporting the growth of Rhizobium. The bentonite clay provided a water absorbing medium within which the bacterial multiplication could take place. These pellets were inoculated with 10^4 nodule bacteria per seed and placed on moistened filter paper for four days, when the numbers of nodule bacteria were counted.

The pellets which gave the desired degree of bacterial multiplication were made from—

A. nine parts by weight of bentonite plus one part of dried blood fertilizer (increase of 1.3×10^3 fold), and

B. 7.5 parts of bentonite plus 2.5 parts of full cream milk powder (increase of 0.5×10^3 fold).

Gelatine and casein gave no multiplication of bacteria in the pellets.

Field trials were then undertaken on two soils derived from granite (sites 1 & 2), and a third on an alkaline sedimentary soil (site 3), in the Armidale district of New South Wales, where failure of nodulation of subterranean clover has been a long standing problem.

Seed pelleted as described was inoculated with commercially prepared peat inoculant at the normal rate of application and was sown in 12 feet rows between rows of unpelleted seed inoculated with the same numbers of Rhizobium per seed. Other treatments were included which are not relevant to this account and all were randomized in plots which were replicated twice at each site.

Three weeks after sowing, samples of the seedlings from dried blood pelleted and unpelleted seed were taken and numbers of *Rhizobium trifolii* per centimetre of main root were estimated according to the method described by Hely, Bergersen and Brockwell (1957). Four or five weeks later the remaining plants of all treatments were dug up and the numbers of nodulated plants and the pattern of nodulation were recorded.

The results are summarised in Tables 1 and 2 from which it will be seen that the bentonite-dried blood pelleted seed consistently produced seedlings with increased numbers of nodule bacteria in the upper rhizosphere and this was correlated with a marked increase in the percentage of nodulated plants.

TABLE 1

The effect of pelleting on rhizosphere numbers of Rhizobium trifolii for 3-week-old seedlings of subterranean clover: near Armidale, N.S.W.

	Numbers of *Rh. trifolii* in the first cm of main root of 4 plants		
	Site 1	Site 2	Site 3
Unpelleted seed	0	0	10
	0	1	0
	>1,000	100	100
	0	0	0
Pelleted seed (bentonite-dried blood)	1	>1,000	>1,000
	>1,000	>1,000	>1,000
	>1,000	>1,000	>1,000
	>1,000	>1,000	1

The bentonite-milk powder pellets also produced improved nodulation on all sites but on only one site was the improvement as great as with the dried blood as the organic constituent. In addition the nodules in the pellet treatment were mostly high on the main root indicating early nodulation and consequently a minimum period of nitrogen stress.

TABLE 2

The effect of pelleting on nodulation of 7-8 week old seedlings grown in problem soils. (Subterranean clover: near Armidale, N.S.W.). Per cent. plants modulated a. near the crown, b. anywhere on the roots.

	Site 1		Site 2		Site 3	
	a	b	a	b	a	b
Unpelleted seed	16	26	21	26	8	8
Pelleted seed (bentonite-dried blood)	84	84	71	78	42	50
Pelleted seed (bentonite-milk powder)	63	63	81	86	18	27

Conclusions

These results were obtained with the plants subjected to severe aphid attack. It seems likely that in good seasonal conditions close to 100 per cent. of plants nodulated could be attained on the granite soils using this type of pelleted seed. The alkaline sedimentary soil still presents a problem although considerable improvement was effected.

All the materials used in the pellets are cheap, only small quantities are required and existing methods of manufacture of lime pelleted seed can be applied. There should therefore be only a small increase in sowing costs compared with unpelleted seed. It is anticipated that the use of such pellets may prove a worthwhile precaution in the sowing of pasture legumes in newly developed areas, since it gives such a large advantage to the introduced strain of Rhizobium. Further investigations are in progress.

In order to maintain a degree of control over the standard of manufacture of seed pelleted in this way, the Commonwealth Scientific and Industrial Research Organization has lodged an application with the Patents Office, Canberra (Application No. 33506/57).

Footnote

It has recently come to the attention of the authors that many commercially available bentonite clays have a pH ranging from 8 to 11, and contain varying amounts of free alkali. Tests have shown that the inclusion in the adhesive of calculated amounts of acids produces satisfactory pellets from alkaline samples of commercial bentonite.

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Effect of Krilium* as a Soil Improver for Glasshouse Tomatoes

Glasshouse tomatoes are produced on a variety of soils in the Sunraysia district. On the heavier soils growers are prepared to incur considerable expense carting light sandy soils into the glasshouse area and digging this into the soil in the belief that this improves soil texture and fertility.

To test the effect of Krilium* as a soil conditioner on two comparatively heavy soils, experiments were conducted during the 1953 and 1954 seasons on a Wentworth loam at Buronga, N.S.W., and during the 1954 and 1955 seasons on a Pomona clay at Nichol's Point, Mildura.

Prior to commencement of the trial on each site, Krilium was dug into the soil to a depth of six inches on replicated plots at the rate of 0, 4.9, 6.9 and 8.9 ounces per square yard on the Wentworth loam, and at the rate of 0, 2.0, 4.0 and 6.0 ounces per square yard on the Pomona clay. The popular South Australian Dwarf tomato variety, trained to a single stem, was grown, in rows two feet three

**Krilium is a trademark of Monsanto Chemical Company.*

inches apart with one foot between plants, in unheated commercial glasshouses 100 ft long by 15 ft wide. Each replicated plot contained six plants and cultural methods commonly practised in the district were used to grow the crop.

The data recorded included first-grade (all sound fruits which weighed two ounces and over) and total fruit yields, mean maturity period (which is considered an index of earliness of ripening) and average weight per fruit of first-grade fruit. The results are given in Table 1.

The yield results show that during the 1953 season on the Wentworth loam there was a reduced yield for one of the treatments (6.9 ounces Krilium per square yard). There were no significant differences however for the other three treatments, and it seems reasonable to assume that this is a chance result. On the Pomona clay, no significant yield differences were recorded in either the 1954 or 1955 seasons.

Krilium had no effect on the mean maturity period as there were no significant treatment

TABLE 1

Effect on yields, mean maturity period and average fruit weight of glasshouse tomatoes from the application of varying amounts of Krilium on two soil types.

Rate of application	Yields in oz/plot of 6 plants				Mean maturity period* (in days)		Average fruit weight (in oz)	
	First grade fruit	Total fruit	First grade fruit	Total fruit				
Wentworth Loam soil	1953		1954		1953	1954	1953	1954
0.0 oz/yd²	417	460	375	406	214	181	3.59	3.51
4.9 „ „	406	450	397	439	215	182	3.62	3.30
6.9 „ „	329	373	348	386	210	182	3.73	3.29
8.9 „ „	392	447	366	404	215	182	3.58	3.18
S.E.:—	±20	±19	±33	±33	±2	±2	±0.17	±0.07
Pomona Clay soil	1954		1955		1954	1955	1954	1955
0.0 oz/yd²	468	531	601	688	181	191	3.25	3.66
2.0 „ „	447	505	627	704	181	189	3.52	3.83
4.0 „ „	442	505	588	668	181	190	3.46	3.61
6.0 „ „	437	508	590	679	185	190	3.38	3.75
S.E.:—	±17	±18	±42	±46	±1	±1	±0.11	±0.65

*For each date of picking, weight of fruit is multiplied by the number of days from transplanting to picking. The products are added together and the sum divided by the total weight.

differences on either site for both seasons of the trial.

The average fruit weight was not affected. In the 1953 season on the Wentworth loam and in the 1954 and 1955 seasons on the Pomona clay, there were no significant treatment differences. In the 1954 season on the Wentworth loam, treatment differences were significant at the 5 per cent. level with weight decreasing as the amount of Krilium increased. The differences were small, however, and may be due to chance.

From the results given in Table 1 it will be seen that under the conditions of the trial, the application of Krilium to the soil had no effect on yield, earliness of ripening or average fruit weight of glasshouse tomatoes. It was noticed, however, that soil texture, particularly on the heavy Pomona clay, was improved, and it is considered that this is of some value for cultivation purposes.

It is not known whether any advantage, apart from possible improvement of soil texture, is achieved by digging light sandy loams into the heavy clay soils.

The results suggest that soil type had little influence on the ripening of tomatoes as, during the 1954 season, when seedlings were transplanted on the same date on both the Wentworth loam and the Pomona clay soils, similar results for the mean maturity periods were recorded for each soil type.

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A Record of Natural Crossing in Subterranean Clover

Natural hybridization in subterranean clover (*Trifolium subterraneum* L.) has so far not been reported; indeed, Australian workers who have had single plants in extensive strain trials under close observation, affirm the absence of natural crossing. Under Australian conditions the species is thus regarded as completely self-fertilizing, though the heterogeneity of collections in its native Mediterranean habitats suggests the likelihood of some natural crosses under conditions where pollinating insects or other environmental conditions may favour pollen transfer. However, no specific tests have been recorded, hence, in view of the evolutionary as well as the experimental interest attaching to the breeding system in this important pasture species, such a test is reported here.

The most likely occurrence could be expected where one parent was male sterile. Enquiries led to promising material, derived from a cross Yarloop x Burnerang, which was kindly supplied by Dr. J. Millington, of the Institute of Agriculture, University of Western Australia. It was subsequently found that though few if any of the plants were wholly male sterile, many had defective pollen, in line with observations by Morley *et al.* (1956) in certain crosses within this species. This factor no doubt accounted for some reduction in fertility, which, however, was further impaired by a severe attack of yellow leaf virus.

The test for natural hybridization was conducted in the field at the Dickson Experiment Station, Canberra, in 1953. Single plants of the F_4 (Yarloop x Burnerang), all of which had normal green leaves, were interplanted with the Red Leaf strain, a selection from the Mt. Barker strain made by Miss Y. Aitken. The red-leaf character is due to a single dominant gene, hence a natural hybrid of a green-leaved plant with Red-Leaf as the pollen parent would be readily identified.

Of the 268 green-leaved plants, 158 were harvested.

Seed production was as follows:

Seeds/plant—	0	1-10	11-20	21-100	>100
No. plants—	22	26	18	56	36

Assuming that the probability of finding natural hybrids would be highest in plants with the lowest seed production, seed from the 40 plants yielding 1-20 seeds was planted. Of the 513 seeds sown, 306 germinated. All seedlings had the green leaf character.

Subsequently the class with the largest number of seeds was sown, viz. the 36 plants yielding more than 100 seeds. Of the 8,971 seeds, 1,121 germinated. Among these seedlings, two, from different mother plants, had red leaves.

It should be noted that the entire material exhibited extreme hardseededness. In the first experiment, the testa of the ungerminated seeds was removed. This was not possible in the second, much larger, experiment, hence the lower germination percentage.

Seeds from the two red-leaved plants were planted and gave the following progenies:

Plant A: 24 red, 9 green.

Plant B: 40 red, 13 green.

These data prove that the parent plants were heterozygotes and thus agree with the expectation of natural hybridization. This clearly indicates natural hybridization, since mutation can be excluded in view of the extreme rarity of the very striking red-leaf mutant in the field and in experimental plantings.

The part which reduced pollen fertility may have played in this experiment cannot be accurately assessed. It should be noted that no hybrids were found in the progenies of the least fertile plants; and while there was reduced pollen fertility in many plants, seed set in the class in which the hybrids were found was, considering the severe virus attack, not abnormally low. The flowers which were cross-fertilized may thus have been fully male-fertile.

The experiment thus shows that natural hybridization in subterranean clover may occur in Australia, though, as far as the evidence goes, with a very low frequency. Yet even at this rate it may give rise to hybrid swarms of distinctive evolutionary significance.

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The Bud Strain of *Eriophyes vitis* (Pgst.) in Australia

For more than 100 years the mite *Eriophyes vitis* (Pgst.) has been recognised as a pest of the grape producing Erinose—a condition characterized by typical leaf deformations. More recently Smith and Stafford (1948) described the occurrence of a bud strain of *E. vitis* which causes considerable damage to *V. vinifera* varieties in California without producing leaf galls. They describe as symptoms stunted cane growth, short basal internodes, scarification of the bark of the new shoots, flattened canes, dead terminal buds on the new canes, witches' broom growth of new shoots, zigzagged shoots, and dead overwintering buds, connected in severe cases with reduced yields.

The Erinose strain of *E. vitis* has been known in Australia for many years. Its damage, restricted mainly to the variety Gordo Blanco (Syn. Muscat of Alexandria), is not regarded as very serious and satisfactory control can, in most cases, be obtained by a pre-bud burst application of lime sulphur.

At the Commonwealth Research Station, Merbein, buds of various grape varieties have, for a number of years, been microscopically examined to determine their fruitfulness. Eriophyid mites were always found in varying numbers irrespective of whether the variety examined showed Erinose during the growing season or not. Whenever they were identified they were morphologically indistinguishable from *E. vitis* (Keifer, 1952).

About 3,500 buds from sultana vines are examined annually. In 1956 and 1957, when records of their occurrence were kept, mites were found in 3.3 and 5.5 per cent. respectively of all the buds. It is important to note that no actual search for mites was made and that as many bud scales as possible were removed before examination under the microscope. Only colonies of some size which had entered some distance into the bud were therefore recorded. Most of the affected buds were at the base of the cane but there is evidence that some infestation does occur in more distal buds.

Usually about one third of all sultana buds retained at pruning remain dormant. Quite a number of them have already died by the end of autumn and the remains found in them indicate that some were killed by mites. In spring 1956 the buds which had not burst on ten vines were microscopically examined to try to find the cause of their remaining dormant. Approximately 10 per cent. of these buds, some as distal as bud position 13, contained mites. Most of the shoot symptoms mentioned by Smith and Stafford (*loc. cit.*) can be found on the sultana during careful field observations but none are frequent enough to cause any economic damage. As the main infestation occurs in the basal buds which play no important part in the production of the crop it is unlikely that *E. vitis* does reduce sultana yields to any extent at the present time.

Waltham Cross buds were found to be more severely infested. In the winters of 1952, '53 and '54 the first five buds on canes sampled at Woorinen were examined, and 64, 40, and 61 per cent. respectively of all buds contained *E. vitis*. Of all buds examined 19, 21, and 20 per cent. respectively were dead. This proportion of dead buds must result in a considerable reduction in bud burst, at least of primary buds, on this spur-pruned variety. If the mites kill these buds, as seems likely, they are obviously causing economic damage. The damage would even be greater if any weakening of the infested but surviving buds does occur.

Ohanez buds were microscopically examined during winter 1956. Approximately 25 per cent. of all buds were infested by *E. vitis* and, in contrast to the sultana, these buds were more or less uniformly distributed along the whole length of the cane. Samples were taken from vines in the Sunraysia, Robinvale, and Mid Murray areas and all showed a similar degree of infestation. In a considerable number of infested buds parts of bracts, leaf or bunch primordia, or the shoot apex itself, were distorted or dead. Crops harvested from the vines used for bud sampling were considerably smaller than would have been expected from the estimate of fruitfulness. In fact during spring bunches were observed which failed to develop and eventually abscissed (Figure 1). In spring 1957 the burst of six canes on each of three vines was followed in detail. When bud burst was complete 150 of the 213 shoots present were fruitful, but on 39 shoots one or both inflorescences failed to survive. In all only 74 per cent. of all the bunches present at bud burst developed to the flowering stage. Damage normally attributed to bud mite attack, namely zigzagging of the shoot, shortened basal internodes, and leaf distortion, was found on 77 per cent. of the shoots which lost inflorescences, but on only 13 per cent. of those which retained them. Similar damage, including disappearing inflorescences, was also observed on other sites. No direct proof can

Figure 1 Left: Shoot with degenerating bunch opposite 4th leaf. Normally developing bunch opposite 5th leaf. Right: Degenerating bunch.

be given that the loss of bunches in the Ohanez is due to *E. vitis* but circumstantial evidence strongly supports such a conclusion.

Gordo Blanco buds, examined in winter 1955, were quite extensively infested by *E. vitis*. Severe damage to bunch primordia and other tissue inside the bud was evident, and this could not be attributed to the Erinose strain of the mite which is generally found on this variety. Mild infestation without any apparent damage was also found in currant buds.

Conclusions

It appears that the bud strain of *E. vitis* infests all the important grape varieties grown in the irrigated vineyards of the Murray Valley. The amount of damage varies with variety, and in some appears to be of considerable economic importance. Control has up to now proved impossible due to the mites' well protected habitat inside the bud. Invasion of the newly forming buds starts as early as the middle of October, two to three weeks after bud burst, and the mite never remains in the open. An exact evaluation of the damage it causes will not be possible until complete control on at least an experimental scale can be achieved. Work along these lines is proceeding.

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The Species of *Ephestia* Infesting Dried Fruit in Victoria and South Australia

During the 1956-57 crop season an investigation of insect infestation in dried fruits was undertaken in Victoria and South Australia. Larvae and adults of the genus *Ephestia* (Phycitidae, Lepidoptera) were prominent among the insects collected.

In 1927 Myers reported *Ephestia* as common in packing sheds in the area. He identified the material as *Ephestia cautella* (Walk.) using the key of Meyrick (1895). This identification was confirmed by A. J. Turner. In 1936 adult *Ephestia* from Merbein, submitted to the C.S.I.R. Division of Economic Entomology, were identified as *E. figulilella.* (Greg.) (C.S.I.R. 1937).

During the present investigation specimens of *Ephestia* were collected by the author on the following occasions.

December 1956. Spun up larvae from under the bark of trellis poles among vines at Merbein, Victoria.

Spun up larvae from the walls of a packing shed at Redcliffs, Victoria.

February 1957. Empty pupal cases from under the bark at Merbein.

Live and freshly dead adults from the window sills of packing sheds at Renmark and Berri, South Australia.

One live adult from dried peaches in packing shed at Renmark.

April 1957. Larvae from currants, recently received from the growers, at packing sheds at Renmark and Mildura. On this occasion a total of 394 larvae was collected.

The adults were identified by means of the genitalia using the figures of Pierce and Metcalfe (1938) and of Heinrick (1956). All proved to be *E. figulilella* with the single exception of the specimen taken from dried peaches in February. This was *E. cautella.*

Myers' adult material was determined by the examination of superficial characters now known to be unreliable for the genus *Ephestia.* Heinrick (1956) states "the genitalia are distinctive but there are no consistent superficial characters for the separation of *figulilella* from *cautella*".

When the larvae were examined it was found that no keys were available in the literature for the separation of *E. figulilella* and *E. cautella,* both species keying out *E. cautella.* Subsequently E. T. Bezant (personal communication) provided a description of characters that enabled the larvae of the two species to be separated satisfactorily. It was then found that the larvae collected on all occasions were *E. figulilella.* Their identity was confirmed by rearing some of the larvae and examining the genitalia of the resulting adults.

The question arises whether the relative abundance of the two species has changed greatly since the 1927 investigation by Myers or whether his specimens were incorrectly identified. The most comprehensive description of the biology and behaviour of *E. figulilella* appears to be that by Donohoe *et al* (1949). A comparison between that descrip-

tion and the report by Myers reveals no observation by the latter that would eliminate *E. figulilella.* On the other hand Myers' remarks concerning the behaviour of full grown larvae among fruit arriving at the packing shed exactly parallels behaviour witnessed by the author during the 1956-57 season. Myers does, however, make the statement that "no dried fruit insect is interested in the grapes on the vine" whereas Mackie (1932), Kaloostian *et al* (1941) and Donohoe *et al* (1949) report that larvae of *E. figulilella* feed on ripening grapes in the United States. During the present investigation the author failed to find larvae on unharvested fruit.

In view of the evidence, it seems most likely that Myers' material was incorrectly identified and that *E. figulilella* has been widespread in the fruit growing areas for many years.

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S. W. BAILEY.

Division of Entomology,
C.S.I.R.O.,
Canberra.

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THE UNIVERSITY OF NEW ENGLAND

APPOINTMENT IN POULTRY SCIENCE

Applications are invited for an appointment as Lecturer or Senior Lecturer in Poultry Science in the Faculty of Rural Science. The salary range for a Lecturer is £A1500 x 90—£A2050 and for a Senior Lecturer is £A2220 x 80—£A2500. In addition a cost of living allowance amounting to £A11 (males) and £A9 (females) is payable.

Provision for superannuation, study leave, assistance in buying a house and removal and travelling expenses.

Conditions of appointment and further information may be obtained from the undersigned or from the Secretary of the Association of Universities of the British Commonwealth, 36 Gordon Square, London.

T. C. LAMBLE,
ACTING REGISTRAR

Armidale, N.S.W.

Thesis Summary

Microscopic and Submicroscopic Organisms in the Soils of the Macquarie Island Ecosystem

The terrestrial ecosystems of the subantarctic are incompletely understood. A serious deficiency is that very few studies have been undertaken of the soils and their microbiology. The information at present available has been summarised. A general description has been given of Macquarie Island which shows it to be an area well suited to investigations of the above description.

The soils have been described in sufficient detail to provide a basis for the microbiological account and a tentative topographic sequence has been suggested which should be useful if a full-scale pedological study is undertaken at some future time. Lithosols and a number of organic soil groups are represented.

An attempt has been made to list, as completely as a survey study would allow, the groups, genera or species of submacroscopic and micro-organisms living in the soil and acting as parasites and saprophytes on the vascular flora. The diversity of the so-called "primary microbiotic complex" has been shown to be remarkably wide. Two groups, the diatoms and the fungi, were examined in particular detail.

An examination was made of the individual microbiotic complexes (dependent variables of the ecosystem) of the soils by attempting to find the distribution of the components of the primary microbiotic complex in a number of representative soil situations and by qualitative characterisation of individual complexes. A scheme comparable to that used in normal plant ecology has been used to explain the findings. A brief ecologic statement has been given relative to the organisms parasitic on the vascular flora.

The effect of environmental conditions including the rhizosphere influence of the vascular flora on the numbers and activities of the important components of the primary microbiotic complex has been studied. Particular attention has been paid to the decomposition of organic matter mainly in terms of metabolic activity, and to the nitrogen economy of the soils. The importance of nitrogen additions in sea spray has been indicated.

Finally, the state of development of the soils of Macquarie Island has been discussed and the relative importance of micro-organisms in this respect indicated. A short comparative account has been presented of other subantarctic landmasses showing the types of soil that might be expected throughout the region.

J. BUNT.

Awarded the degree of Ph.D. by the University of Sydney, 1957.

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Talks

The Melbourne Milk Supply has both Quality and Efficiency

Presidential Address by T. S. Bellair to the Victorian Branch, March 28, 1958

The Melbourne metropolis and three smaller areas—(Bendigo, Latrobe Valley and Mornington Peninsula) which come under the Milk Board control, consume an average of 160,000 gallons per day. The farmers supplying this milk receive £10m. per year or £200,000 per week.

The public pay £20m. per annum for this milk and approximately £2m. for cream which represents about £60,000 each day.

The Milk Board fix the price for the farmer, the margin paid to the processor and vendor, cartage rates and so the retail price. In the case of the farm price a continuous cost survey is made on 150 farms which are distributed in relation to the quantity of milk supplied by the various areas. The other margins are based on cost studies in the processing and retail trade.

Each supplier has a contract daily quantity and he is expected to maintain this quantity throughout the year. Should he drop below this amount for a period without a reasonable excuse (such as unfavourable seasonal conditions) his contract quantity will be reduced and distributed among other suppliers who have maintained their production.

In terms of butter fat the present Milk Board price represents about 7/6 lb. for a 40% milk compared with about 4/6 lb. received by those supplying milk for manufacturing. However, it must be remembered that a contract farmer has to maintain a uniform production throughout the year, reach a high standard of hygiene, deliver milk to the factory or a road stand twice a day throughout seven and a half months of the year. Compare the position of a farmer who is selling milk to a cheese factory or separating and who may farm out most of his herd during the winter months.

To be a high quality a milk supply should—

(a) Come from healthy cows and be produced under hygienic conditions. Have a reasonable butter fat content.

(b) Be efficiently pasteurised, protected from re-contamination and packed in sterile containers.

To be efficient, milk should reach the consumer at as low a price as practicable.

Comparison Between the Australian Capitals

	Farmer's Price	*Bottling & Delivery*	*Retail Price of Quart*
SYDNEY	4/3¾	2/10	1/11
BRISBANE	3/3½	2/5	1/7
ADELAIDE	3/2¾	3/1	1/7
PERTH	3/5	2/6	1/7
MELBOURNE ..	3/4½	2/6	1/6½
HOBART	4/1	N.A.	1/8

In the case of Melbourne the farmer's price is that delivered to Melbourne so that the cartage costs reduce the price to below 3/- in outer districts. The farmer's price plus bottling and delivery costs do not necessarily add up to the retail price as in some states additional cartage costs come into the price structure.

In regard to processing Melbourne differs from the other Australian Capitals having 30 pasteurising and bottling plants. The largest plant in Melbourne handles 15,000 gallons per day, whereas a plant in Sydney processes nearly 100,000 gallons and one in Brisbane 45,000 gallons. Melbourne's plants work only one shift and these Melbourne plants are more efficient because of the closer supervision possible by proprietors or heads of companies. While it may appear that larger plants than those in Melbourne could operate more economically this is not borne out by results.

As a result of work over the past four years by a graduate of our School in Melbourne—Mr. Peter Webster—there has been a marked improvement in the quality of the milk bottles produced for the Melbourne milk trade. Bottles average 60 trips so that the cost for each use is only one-tenth of a penny. Single service containers cost up to 2d. for a pint size.

Before the war few milk carts delivered more than 170 quarts each morning. However, during the war to conserve labour etc., rounds were zoned and since the war the trade has continued to consolidate its rounds so that today most carts deliver over 400 quarts daily. As drivers' wages have increased more than fourfold over this period, it can readily be seen how the public have gained from the more efficient delivery system.

The market cream trade in Melbourne is highly developed and by producing a high grade and good keeping product at a reasonable price, the consumption is four times higher than that of Sydney.

Cream Consumed per Head

Expressed as Milk Equivalents in Gallons.

SYDNEY	1.5
PERTH	1.8
BRISBANE	2.4
ADELAIDE	3.9
MELBOURNE	5.8

Mr. Bellair concluded by pointing to the title of his address and felt that he had shown amongst other things that Melbourne has the highest quality milk supply in Australia yet it is delivered to the customer at the lowest price of any Australian city.

The Effect of Settlement on Australian Vegetation

Mr. R. Milton Moore, Asst. Chief, Division of Plant Industry CSIRO, in an address to the South Australian Branch

Mr. Moore traced the association of many common plants and weeds with man and his activities right through the ages to the present day. He pointed out the close association between the religious beliefs of people in early history and the names attached to various plants and how these names were modified through the ages depending on current religious and political beliefs. The medicinal value of many plants was early recognised and plants followed man in his explorations.

The speaker drew attention to the amazing similarity between native genera and even species from widely separated parts of the world. Furthermore many of the native plants have generic links with introduced plants including weeds and so the new introductions quickly adapt themselves to the environment. The concept of controlling weeds by controlling their habitat is of well-known importance.

The main theme of Mr. Moore's talk was the effect of sheep grazing on some of the important native communities in Australia. The native pasture, originally lightly grazed by indigenous marsupials, was, over a comparatively short period, subjected to concentrated grazing by sheep. By 1890 there were some 100,000,000 sheep in Australia and even now, with the large areas of improved pasture, the sheep numbers have only increased to about 150,000,000.

The early settlers felled and burned timber to promote growth of grass, imported and sowed seeds containing weed impurities, and, having denuded areas to varying extent by grazing, moved on to new areas leaving behind the nuclei of new plant communities.

Considering various communities:—

Dry sclerophyll forest communities: These occur on skeletal soils low in nutrients. In New South Wales the typical community is *Eucalyptus Rosseri —E. macrorrhyncha* whereas in South Australia it is *Eucalyptus Obliqua—E. Baxteri*. In the native state there was only a very sparse covering of grass (*Themeda australis*—Kangaroo grass and *Danthonia pallida*—Wallaby grass). Under grazing by sheep the *Themeda* quickly disappeared giving way to *Danthonia* with a consequent drop in grazing value. The more recent understanding of trace element deficiencies, in particular molybdenum, has completely changed the potential of these dry sclerophyll forest areas.

Woodland communities: These are of three types —savannah woodland, scrub woodland and tall woodland—all typified by the park-like appearance with spaced trees and grass beneath. These communities provided the main grazing areas of the early settled parts, e.g. redgum and blue gum areas of South Australia.

The woodland community soils include the meadow podsols and red brown earths which have a higher calcium content than the sclerophyll forest soils. The woodland soils carried, high, 3 tons/acre stands of *Themeda* on the Adelaide plains in the early days but with grazing these stands quickly disappeared and were replaced by *Danthonia* and *Stipa*.

The general trend following grazing in the woodland zones has been from *Themeda* (tall summer growing perennial) to the shorter winter growing perennial species of *Danthonia* and then to the introduced annual species with sort growing season These included *Trifolium glomeratum* and *T. dubium* on the podsolised soils (e.g. meadow podsols) and *Medicago denticulata* on the red brown earths.

Following topdressing with superphosphate a rapid change came about. Subterranean clover became widespread and with the improved nitrogen level inferior grasses, thistles and capeweed invaded the pastures of the meadow podsol areas whereas *Medicago denticulata* plus inferior weedy species predominated in the red brown earth areas. The introduced annuals have a higher protein content but a shorter growing period than the native perennials.

Mr. Moore stated that, under grazing, different communities could often finish up the same where the country had been denuded of its original vegetation. As evidence of this he discussed a transect from Mount Kosciusko towards Canberra. Although native communities differed greatly due to altitude

etc. there was a general trend towards uniformity and there was a marked similarity between communities of denuded areas irrespective of native vegetation, soil type and climate.

In summarising the speaker said that following grazing, there had been a general trend from a summer growing perennial (e.g. '*Themeda*) to a winter growing perennial (e.g. *Danthonia*) and then to winter growing annuals. The gradual decreases in the length of the growing season had been accompanied by a corresponding increase in protein content of the herbage.

Mr. Moore concluded with a plea for the preservation and extension of the number of National Trust Areas where long-term changes in plant communities could be studied.

Book Review

AGRICULTURAL CO-OPERATION IN THE UNITED KINGDOM

By Margaret Digby and Sheila Gorst

Co-operation is a word often misused. In its broadest sense it means working together for a common goal. But since the great social experiment initiated by the Rochdale weavers in 1844, co-operation has assumed a more definite meaning and is applied to a voluntary association of people intent on some activity for their own mutual benefit. This book gives, in a condensed yet very readable form, an up-to-date outline of the growth, structure and operation of co-operation in Great Britain. It shows, too, how the principles of co-operation have been reconciled with the traditional individualism of the farmer.

Co-operation is a complex phenomenon which includes both social and economic objectives and is governed by principles sufficiently fluid and flexible to adapt itself to many different activities under a wide range of circumstances. This is well illustrated in chapters dealing with co-operation in agriculture in England, Scotland, Wales and Northern Ireland and its application to the agricultural requirements, general marketing, and the variety of services which reflect the physical and social environment of agriculture in those countries. The inherent weaknesses of co-operation are dealt with in chapters on finance, membership relations, staff training, and the association of the co-operatives with one another.

The authors sum up the position of co-operation in the British agricultural economy and conclude with a glimpse into the future in the light of problems inclined in some instances to be peculiar to co-operation and which apply, although with a slightly different emphasis, to co-operation here in Australia. The book is a useful addition to literature on co-operation and achieves a happy blending of the philosophical doctrine of co-operation with a factual account of the operations of co-operative units in agriculture in the United Kingdom.

HEDLEY C. CLARK

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News Items

Travelling Awards for Australian Farmers

The Nuffield Foundation is continuing this year its practice of offering two travelling scholarships to enable progressive Australian farmers to spend a period of not less than six months gaining experience in the United Kingdom.

The Foundation will pay the scholar's return travelling expenses, at tourist rates (by air if really necessary), and will provide a living allowance. If needed, an allowance will be made towards meeting the cost of running a farm whilst the scholar is abroad. The Foundation will arrange the scholar's itinerary in the United Kingdom to ensure that he gains the maximum benefit from his stay. Candidates, who may be male or female, should be over 25 but not much over 35 years of age.

The applicant's capacity to communicate his experience to other farmers on his return to Australia will be taken into account in making the awards.

This year's scholarships to be taken up early in 1959 are being offered to farmers in New South Wales, the Australian Capital Territory and Queensland. Next year's award will be offered in South Australia, Western Australia and Northern Territory. They were made last year in Victoria and Tasmania.

Fuller particulars of the scheme and application forms may be obtained from the Secretary of the Nuffield Foundation Australian Advisory Committee, C/o University of Melbourne, Carlton, N.3. Applications for the present awards will close on 11th July, 1958.

Australian Agrostology Conference, 1958

At its 54th meeting, the Standing Committee on Agriculture requested CSIRO to convene an Australian Agrostology Conference in 1958. The Conference will be held at the University of New England, Armidale, New South Wales, during the week commencing December 8, 1958.

The broad subject headings which have been suggested for discussion at this Conference are:—

1. Pasture Utilization.
2. Pasture diseases and insect pests.
3. Nitrogen relationships of pastures, including nitrogen fertilization.
4. Conservation of pastures as hay and silage.
5. Mineral nutrition.
   (a) Old Pastures.
   (b) New Pastures.
6. Animal health problems associated with pasture improvement.
7. Regional pasture problems.

Special addresses—Pasture plant breeding; growth and development of pasture plants in relation to defoliation; weeds of pastures.

The Organising Committee consists of:—

Mr. R. M. Moore, CSIRO, Canberra (as Chairman).
Associate Professor R. Roe, CSIRO, Armidale.
Dr. J. Griffiths Davies, CSIRO, Brisbane.
Mr. S. Marriott, Queensland Department of Agriculture.
Mr. N. S. Tiver, South Australia Department of Agriculture.
Mr. F. Crofts, University of Sydney.
Mr. J. H. E. Mackay, Secretary.

Fruit Research Conference Adelaide — August, 1958

A Fruit Research Conference is to be held at the Roseworthy Agricultural College, South Australia from 4th-7th August, 1958. It is being convened for the Australian Agricultural Council by CSIRO in conjunction with the South Australian Department of Agriculture and Roseworthy Agricultural College.

The Conference will be concerned primarily with research relating to practical problems of Australian fruit culture. The emphasis will be on applied research which will be discussed on a subject rather than a crop basis.

The main basis for discussions will be Australia-wide reviews of selected subjects prepared by individual officers. In this way it is hoped to obtain maximum benefit from the conference.

The conference will consist of nine sessions at each of which one or more reviewers will lead the discussion. The official opening will be at 10.30 a.m. on Monday, 4th August. The subjects for discussion are as follows:

Session I—Horticultural experimentation.
Session II—Fruit Nutrition.
   (1) Use of fertilisers:
      (a) Major elements.
      (b) Trace elements.
   (2) Fruit quality effects.

Session III—Soil Management.
(1) Water relationships.
(2) Cultural systems.
Session IV—Crop physiology.
(1) Bud initiation and development.
(2) Effects of heat and cold units on growth.
(3) Crop regulation.
(4) Fruit growth control.
Session V—Rootstocks.
(1) Apples and Pears.
(2) Stonefruit.
(3) Vines.
(4) Citrus.
Session VI—Fruit Harvesting and Handling (excluding storage).
(1) Harvesting.
(2) Preparation for Market.
Session VII—Pruning.
Session VIII—Horticultural Aspects of Spraying.
Session IX—Fruit Variety Introduction and Improvement.

Joint Secretaries for the Conference are—Mr. P. F. Butler, CSIRO, 314 Albert St., E. Melbourne and Mr. H. P. C. Trumble, Department of Agriculture, Gawler Place, Adelaide.

E.S.U. Scholarships

The Younger Members' Group of the Victorian Branch of the English-Speaking Union offers, in 1958, its third annual Travelling Scholarship.

The Scholarship will take the form of a Grant to the value of £A200, and is open to all young men and women whose ages fall within the prescribed limits at the closing date for applications, and who will be proceeding to the United Kingdom or the United States of America within twelve months from 30th June, 1958.

Applications will be received from men and women who are British subjects resident in Australia, and who are between the ages of twenty-one and thirty-five years on 30th June, 1958. A Selection Committee will be appointed by the Younger Members' Group of the Victorian Branch of the English-Speaking Union. They will give consideration to the human and outside interests, potential good ambassadorship and professional or practical qualifications of candidates. The successful candidate may be given the opportunity to address English-Speaking Union branches overseas, or on return to Australia.

In addition to the £A200 Grant, it is hoped to arrange some hospitality in the United Kingdom or the United States of America for the successful candidate.

Application forms are available from the Executive Officer or the Secretary, English Speaking Union, 146W Toorak Rd., South Yarra, Melbourne. Applications close on 30th June, 1958.

First World Livestock Disease Report Issued

The first World Livestock Disease Report, covering the year 1956, jointly prepared by the Food and Agriculture Organization of the United Nations (FAO) and the International Office of Epizootics (OIE) has now been issued. The information contained in the report provides an overall picture of the animal disease position throughout the world. This knowledge and the resulting action which may be taken will doubtless contribute considerably to the improvement of human and animal health and prove a great benefit to the economy of all countries.

The report will be particularly useful to the veterinary authorities, namely when imports of animals and animal products are being considered, or where traffic of animals into or through a country, from another part of the world, takes place.

The document has been prepared on the basis of a list of diseases which were put on a special list established in collaboration with OIE. Particulars of the occurrence of the diseases, length of time in a country and information concerning their intensity were requested from the veterinary services. OIE simultaneously distributed the form to those of its members which are not also members of FAO. Some 80 countries provided the information requested, not only on infectious diseases but also on diseases of economic importance.

A coding system used in the report, will assist in the analysis of the documentation provided, making it possible to obtain information on the progress of measures taken to control any of the diseases mentioned from year to year. From such details it should be possible to build up a world picture of disease control, methods adopted and progress made.

It is the intention of FAO to issue in the future a Yearbook on Animal Health, which would not only include the incidence of animal diseases as coded in the present report, but would also give a fuller picture of the disease situation including latest techniques and measures taken for the control of the diseases.

Agricultural Production Survey in W.A.

Some time ago the Avon Valley Zone Development Committee put forward a suggestion for the conducting of a survey within the Avon Valley Zone (Toodyay, Northam, York and Beverley Road Boards). The purpose of the survey would be to make an assessment of the agricultural potential and problems of the zone.

The W.A. Department of Agriculture has undertaken to conduct such a survey which is at present in progress. It is being carried out by those officers of the Soils Division and the Wheat and Sheep Division stationed at the Northam District Office. The general aim of the survey is to provide production figures for the zone to determine whether agricultural production is at the level expected to result from the changes and improvements in farming knowledge and techniques during the last couple of decades.

Each of the sample farms will be visited so that the officers can assist the farmer to complete a questionnaire relating to various aspects and problems associated with land use, cultivation, crops, pastures, fertilisers, rotations, soil conservation, stock, pasture management, stock management, etc.

Extension School in W.A.

During February the Department of Agriculture conducted a two week course at Muresk Agricultural College for the District Agricultural Advisers of the Wheat and Sheep Division. Officers who attended are stationed at Geraldton, Moora, Northam, Narrogin, Katanning, Mt. Barker and Esperance.

The first week was designed to acquaint the general advisers with field techniques and extension work associated with soil conservation. The second week was spent on animal health and nutrition, wool classing, fleece measurement, flock management and general aspects of animal husbandry. During the course there was sufficient provision for discussion and interchange of ideas.

This course is believed to be the first of a series of such extension or refresher schools to enable country officers to be kept up to date with the various specialised subjects.

New Laboratories for W.A. Department of Agriculture

Satisfactory progress is being maintained in the building of the new laboratories and general office accommodation for the West Australian Department of Agriculture. The buildings are situated on a 25 acre site at South Perth, about 3 miles from the heart of the city and will enable the various Divisions and Branches of the Department to be housed together whereas at present they are accommodated in several widely scattered buildings of various types.

Ninth International Botanical Conference

The Ninth International Botanical Congress will be held in Montreal, Canada, from August 19 to 29, 1959, at McGill University and the University of Montreal, and will be preceded by sessions of the Bureau of Nomenclature from August 16 to 19.

Programme

The programme of the Congress is being organized and tentatively includes the following sections:

Nomenclature; General Systematics (including special problems) and Phylogeny; Taxonomy and Geography of Vascular Plants; Phycology; Mycology (including Medical Mycology); Phytopathology (including Virology); Bryology; Lichenology; Microbiology; Morphology and Anatomy; Paleobotany; Physiology; Ecology; Cytology and Genetics; Forest Botany; Ethnobotany and History of Botany.

Membership in the Congress will be open to all persons interested in botany. Institutions and countries will be encouraged to assist botanists in attending the Congress but no official delegates will be recognized.

Botanists who desire a personal invitation are requested to apply to:
Secretary-General,
IX International Botanical Congress,
Science Service Building,
Ottawa, Canada.

Wheat Industry Research Committee of S.A.

Following the passage of the Wheat Tax and Wheat Industry Research Acts of 1957, a levy of ¼d. per

bushel is now being made on all wheat delivered to the Australian Wheat Board. The levy, which operated from the 1956/57 harvest, is paid into a fund to be used to finance research and advisory work to benefit the wheat industry. The money raised in each State is at the disposal of a State Committee, which in South Australia consists of *Messrs. T. Shanahan* (Chairman), *C. T. Chapman, G. C. Bruce* (all wheat growers), *Dr. J. Melville* and *Dr. A. R. Callaghan.*

It is expected that the Commonwealth government will contribute funds up to a level which matches the total industry levy. These funds are to be disbursed by the Minister for Primary Industry on the recommendation of a Wheat Research Council which also has the task of preventing overlapping between State programmes.

The Council will recommend the manner in which the central fund is to be used. In this respect, it has power to recommend the use of central funds to fill in any gaps between State programmes as well as provide funds for Commonwealth organisations.

The South Australian Committee has appointed a Technical Committee to advise it and recommend projects and the allocation of funds. Its membership is *Mr. A. G. Strickland* (Chairman), *Messrs. R. M. Krause, A. J. Farquhar, Professor C. M. Donald* and *Mr. W. F. Nankivell.*

Black Spot Eradicated from N.S.W. Orchards

It is believed that a spray programme which ended two years ago may have eradicated black spot disease of apples from an orchard at Maroota, in the Windsor district. This would be the first time the disease had been eradicated from a New South Wales orchard.

This is the result of work conducted by Mr. K. E. Hutton, Plant Pathologist of the Department of Agriculture N.S.W.

The Department of Agriculture chose this orchard for the experiment because of its isolated position —there is no other apple orchard within five miles.

Severe Infection

At the end of the 1954-5 season the 2-acre plot of apples was severely infected with black spot, or "apple scab". In autumn 1955 it was sprayed thoroughly with 0.1 per cent. phenyl mercuric acetate. In the middle of the next season trace infection occurred in one corner of the block, and a single lime-sulphur spray was applied in December. In autumn 1956 the plot was sprayed thoroughly with 0.1 per cent. phenyl mercuric chloride. No fungicide had since been applied.

During the 1956-7 season the only black spot detected was a trace infection on four leaves, late in the season. These leaves were picked off. No sign of any infection has been detected in the 1957-8 season. The trees produced a heavy crop of good quality fruit this season.

Mr. Hutton said that there was a possibility that the orchard would become re-infected from outside sources. This would almost certainly happen if an orchard were in a less isolated position, unless the eradication programme were applied throughout the locality.

District Test

A district-wide test of the new method of control is in progress at Yetholme, near Bathurst, where 170 acres of apples on 40 properties have been treated.

If the disease could be eradicated in this way it would save growers many thousands of pounds in fruit wastage and the cost of applying many protective sprays each season. The expensive protective spraying programme sometimes breaks down in very wet seasons and allows heavy infection to occur, but a single eradicant spray in autumn prevents infection throughout the next season irrespective of the weather.

General recommendations regarding the eradicant spray will not be made until further investigations are completed.

New Laboratories Opened at Tatura Horticultural Research Station

The Victorian Minister of Agriculture, *Hon. Mr G. L. Chandler, M.L.C.*, officially opened new laboratories costing £60,000 at the Horticultural Research Station, Tatura on April 30. They will enable the station's staff to give a more complete service to fruitgrowers in the Goulburn and nearby Murray Valleys.

The well equipped building actually contains six special laboratories for soils and chemistry, plant physiology, canning, pomology, plant pathology and entomology. When available, a resident entomologist, plant pathologist and chemist will be appointed. The research staff at present numbers 15.

Research will immediately be stepped up on such problems as the treatment of waterlogged soils, which

destroyed more than half of the Goulburn Valley's peach trees in 1956, the control of brown rot in peaches and apricots, more suitable rootstocks for apples and pears, better varieties of peaches and apricots, better fertiliser programmes and the management of various soils.

It is fitting that these additional laboratories should be opened this year—twenty one years since the first plantings were made at the station.

Bank Managers' Conference in Melbourne

Eighty managers and rural staff from every major trading bank in Victoria attended a conference entitled "Fodder Conservation in the Victorian Sheep Industry" at the University of Melbourne early in March. Opened by *Sir Ian Clunies Ross*, the conference was sponsored by the University in conjunction with the Rural Liaison Service of the Commonwealth Bank.

Conference members, mainly from branches in the Western District and north eastern Victoria, heard and discussed the views of experts on fodder conservation who dealt particularly with its place in the high rainfall zone of Victoria. The lecturers were members of the staffs of the University, the Victorian Department of Agriculture and C.S.I.R.O.

Some time ago, a similar conference entitled: "The Changing Pasture Practices in the New England Region" was held at Armidale, N.S.W. During May two more have been held—"Pasture Improvement and Land Development" (Mount Gambier) and "The Changing Pasture Practices in the Southern Tablelands, N.S.W." (Canberra). It is expected that other conferences will be held on Western Australian agricultural development, agriculture in southern Queensland and in the irrigation districts of eastern Australia.

The promotion of these conferences in conjunction with the Universities and other research and extension authorities is one of the functions of the recently formed Rural Liaison Service of the Commonwealth Bank. They will provide an opportunity for bank staff to realise and discuss the possibilities for development of Australian agriculture.

Deputation to the Premier of Queensland

At the request of the Professional Officers Association the Queensland Branch of the Institute was represented in a deputation which waited on the Premier, *Mr. Nicklin*, on the 13th of March, 1958. The deputation sought salary rises and improved conditions of employment for professional and technical officers in the State Public Service.

A sub-committee of the Branch prepared a case which stressed the low salaries payable, the restricted prospects for advancement and the inadequate opportunities for overseas experience received by the Scientific Officers of the State Public Service. Attention was drawn to the crippling shortage of scientific men in the Department of Agriculture and Stock. Out of a total of 237 graduate positions on the permanent staff at that time there were 65 existing vacancies. Since September, 1945, the Department had lost no fewer than 101 male graduate officers by resignation to go elsewhere.

Professor L. J. H. Teakle was appointed Branch delegate and *Dr. W. A. T. Summerville* represented the Federal body of the Institute. Professor Teakle reported that the deputation had been favourably received; the Public Service Commissioner had stated that the salary position would be given sympathetic consideration.

Potash Fertilisers

During 1957 a further large increase occurred in the quantity of potash fertilisers used on crops and pastures in Australia.

The following figures show the tonnages of both Muriate and Sulphate of Potash used in each of the years 1955-7.

	Commonwealth		
Calendar Years	1955	1956	1957
Fruit	4559	4742	5238
Tropical Fruit	2771	3379	3407
Market Gardens	2758	3218	3551
Potatoes	2289	2490	3577
Sugarcane	10341	11056	12539
Tobacco	580	569	582
Pastures	2978	5516	9368
Home Gardens & Sports Grounds	222	257	344
Other Crops	365	447	676
Industrial	—	233	358
TOTALS	26863	31907	39640

The greatest increase in usage has been on pastures, particularly in Victoria and Western Australia and on sugarcane in Queensland. At the present time Queensland uses almost half the total quantity of potash applied (17,451 tons in 1957) and Victoria nearly one quarter (9,458 tons in 1957).

Quantities used in other states during 1957 were as follows: Western Australia 5217 tons, N.S.W. 3225 tons, Tasmania 3175 tons and South Australia 1114 tons.

Visiting Scientists

Since September, 1957, *Dr. E. J. Anderson,* Chief Plant Pathologist of the Pineapple Research Institute of Hawaii has been in Australia for six months as a Fulbright Fellow. During his stay his headquarters were at Sydney University where he conducted all the laboratory work connected with survey of plant parasitic nematodes occurring in cultivated and virgin soils. He sampled soils from many areas in N.S.W. and found that besides the more familiarly known root parasitic nematodes like *Meloidogyne* and *Heterodera,* all the genera of the recently discovered root injury nematodes in America were represented here. Many of these like *Caiconemoides, Helicotylenchus, Pratylenchus* and *Paratylenchus* were found in virgin soil of the natural bushlands. During his stay he visited South Australia, Victoria and Queensland.

He rendered considerable assistance to the training of advanced students in plant pathology in the School of Agriculture at Sydney University.

Enrolments in Agricultural Science Courses—1958

UNIVERSITY	YEAR OF COURSE			
	1	2	3	4
Adelaide	31	19	17	15
Melbourne	78	45	54	38
Queensland	46	33	16	15
Sydney	83	59	61	30
Tasmania	7	—	—	—
Western Australia	29	15	12	7
Totals:	275	171	160	105
ASSOCIATED COURSES:				
Wool Technology (Sydney)	11	5	2	2
Rural Science (New England)	44	16	12	—
Agricultural Economics (New England)	12	—	—	—
Agricultural Engineering (Melbourne)	—	2	1	2

ENROLMENTS: 1951-55 See Journal A.I.A.S. Sept. 1955, p. 194.
1956 See Journal A.I.A.S. Sept., 1956, p. 223.
1957 See Journal A.I.A.S. June, 1957, p. 173.

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Federal President for 1958

Mr. R. Milton Moore

Mr. R. Milton Moore, M.Sc.Agr., Assistant Chief of the Division of Plant Industry, CSIRO, has been elected Federal President of the Australian Institute of Agricultural Science for 1958. Mr. Milton Moore graduated with honours in Agricultural Science at Sydney in 1937. He commenced his professional career with the New South Wales Department of Agriculture in 1937, and joined the Plant Industry Division of CSIRO in 1938, working with the then leader of the Plant Introduction Section, the late Dr. A. McTaggart.

In 1939 he joined the newly formed Agrostology Section under the leadership of Dr. J. Griffiths Davies, the present Associate Chief of the Division of Plant Industry. During that time he instituted and conducted several experiments in problems of grazing management of pastures. He is particularly well-known for his very intensive and complete study of systems of rotational grazing of *Phalaris tuberosa,* Subterranean clover and Lucerne compared with systems of set stocking.

There was an interlude during the war years when he served in the Royal Australian Air Force.

On returning to the Division he was put in charge of the Weeds Section, and his own particular emphasis was the ecological approach to weed problems.

In 1949 he was awarded a fellowship by the Commonwealth Fund of New York and undertook post graduate studies in ecology at Texas A and M College, at the University of California, Berkeley, and at the University of Minnesota. After this he was put in charge of the Ecology Section and in particular directed the study of grazing management on native pastures.

In 1954 Mr. Moore was appointed Assistant Chief of the Division and with it he carries the responsibility of leading and directing the ecologic and agronomic research of CSIRO in southern Australia. As well as the direction of agronomic studies in southern Australia, he has maintained his own personal interests in the ecology of introduced plants and also the ecology of the Australian treeless grasslands.

Members of the A.C.T. Branch of the Australian Institute of Agricultural Science are very much aware of his tireless efforts on the Institute's behalf. He has been a member of the Institute since graduation and has loyally and selflessly served the Branch in the position of Honorary Secretary-Treasurer, as a Committee member, as Vice President, President and immediate Past President. The Institute cannot fail to gain from having so devoted a servant as its Federal President.

The Australian Institute of Agricultural Science Medal

Award for 1958 to Associate Professor J. M. Vincent

The Institute Medal for 1958 has been awarded to Associate *Professor J. M. Vincent* in recognition of his research and teaching contributions in the field of Agricultural Microbiology.

Dr. Vincent is Associate Professor of Agricultural Microbiology in the Faculty of Agriculture, University of Sydney; a position to which he was appointed in 1955. His career prior to that date may be summarised as follows: Graduated B.Sc. Agr. (Sydney) 1933, teacher and lecturer N.S.W. Department of Education 1934-36, Pawlett Scholar Universities of Sydney, London and Wisconsin 1936-39, Assistant Lecturer (1939-42), Lecturer (1943-48) and Senior Lecturer in Agricultural Microbiology (1948-) University of Sydney, Carnegie Travel Grant to Universities in Western Europe, United Kingdom and United States (1949). The degree of Doctor of Science in Agriculture was awarded in 1956.

Associate Professor Vincent is well known for his contributions both to research and teaching. In his research work he has made significant contributions in three major fields; milk bacteriology and grading; inhibition of microbial growth; and root nodule bacteria of pasture legumes. It is in this latter field that his main research interest lies. Phases of this work have included studies of the natural occurrence, distribution and serology of Rhizobia as well as specific relationships between host and bacterium, the ability of "native" strains to fix nitrogen and the establishment of added inocula. This work has been largely responsible for the present day recognition of the vital role played by the root-nodule bacteria in pasture establishment and has provided a basis for considerable practical application. Some of these advances have been achieved by research teams working under his active direction, but his personal contribution at all times has been very real and important.

Associate Professor Vincent's contribution as a teacher of microbiology has been pre-eminent, and the under-graduate and post-graduate training programme at the School of Agriculture in agricultural microbiology (which has been developed under his sole guidance), is at present probably without equal in the Australian Commonwealth. The small but valuable group of graduates who have been trained under his direction occupy important position in Universities, C.S.I.R.O., State Departments of Agriculture and Industrial firms.

Other positions to which Associate Professor Vincent has been appointed or elected include President, Vice President and Principal Delegates of the New South Wales Branch of the Institute, President, Linnean Society of New South Wales, Member of Executive of Australian National Research Council and Fellow of the A.N.Z.A.A.S.

Personal Notes

Australian Capital Territory

Mr. R. O. Slatyer of the CSIRO Division of Land Research has been transferred to Alice Springs for 12 months to take over the responsibilities of officer in charge of the Division's activities in that region.

Mr. C. S. Christian, Chief of the CSIRO Division of Land Research, accompanied by *Dr. E. Phillis* and *Mr. J. Basinski* visited northern Australia in April. At Kimberley Research Station they met representatives of the Western Australian Government and attended meetings of the Kimberley Research Station Policy and Supervisory Committees. They also visited Katherine Research Station and Darwin.

The regional survey units of the Division of Land Research both plan to commence 3 months' field work in early July. The mainland unit, under the leadership of *Mr. J. A. Mabbutt* will carry out a survey in the Wiluna-Meekatharra area of Western Australia in cooperation with *Mr. D. Wilcox* of the W.A. Department of Agriculture and a geologist from the W.A. Mines Department. *Mr. H. A. Haantjens* will be in charge of the New Guinea unit which will work in the Lower Ramu-Atitau area.

Dr. T. G. Chapman was recently appointed to the Division of Land Research to undertake research in arid zone hydrology. Dr. Chapman who was previously lecturer in hydraulics at the University of Southampton arrived in Canberra last November and will investigate the water balance of selected areas, with the objective of determining the possibilities, in appropriate locations, of greater use of surface flow by water spreading or of development of shallow groundwater for local small scale irrigation.

Dr. O. H. Frankel left recently for a seven months trip abroad. He will visit Israel and Cyprus before proceeding to Europe, and will visit biological research centres in all countries. He will return via the U.S.A.

Mr. J. K. Taylor and *Dr. Stephens* of the Division of Soils CSIRO Adelaide recently visited Canberra for discussions with the Chief and research officers of the Division of Plant Industry concerning a co-operative study of the soil conditions governing pasture productivity under irrigation in the Riverina irrigation areas.

Dr. D. S. McIntyre recently returned from the University of Wisconsin U.S.A. where he received a Ph.D. for his work on soil structure in relation to plant growth. He is now soil physicist attached to the South-Eastern Regional Centre of the Division of Soils, CSIRO Canberra.

Mr. B. Breese, a recent graduate in Geology from the University of Western Australia has been appointed to the microscopy group of the South Eastern Regional Centre of the Division of Soils, CSIRO Canberra.

Mr. J. R. Freney of Armidale has been awarded a position of junior specialist which will allow him to study at the Kearney Foundation of Soil Science, Berkeley, California for twelve months.

Mr. J. J. Yates, who has since April this year been stationed at Canberra in the Genetics Section, has now left to take up his appointment at the Plant and Soils Laboratory, Brisbane.

Dr. J. V. Possingham, who has for the last two years been on a CSIRO studentship studying problems of plant nutrition at the Department of Agriculture, University of Oxford, has recently returned to Canberra.

Mr. J. R. McWilliam, a graduate in Science and Forestry from the Queensland University has been appointed to a research position with the Genetics Section. Initially he will be stationed in Canberra where he will take part in the pasture plant breeding programme. Mr. McWilliam was formerly in charge of the Forest Genetics programme of the Queensland Forestry Service but more recently has been engaged in post graduate studies at Duke and Yale Universities. His most recent work has been on the problem of interspecific incompatibility in *Pinus* and *Picea.*

Miss B. J. Ballantyne, a graduate in agricultural science from the University of Sydney has been appointed to an experimental officer position with the Microbiology Section. Miss Ballantyne will assist with investigations into the host pathogen environment relationships of brown rot in Australian stone fruits. This work will form part of a co-ordinated programme of research into this disease. The stone fruit industry has been instrumental in initiation of the programme and is contributing funds towards its support.

Miss C. Warner, an agricultural graduate from the University of Sydney has been appointed to an experimental officer position with the Plant Introduction Section in Canberra. Miss Warner will be concerned primarily with the collection and collation of data on the taxonomy, distribution and economic value of introduced plant species.

New South Wales

Mr. S. M. Sykes has resigned as Senior Research Officer, Fruit, with the N.S.W. Department of Agriculture, to take up appointment as Leader, Food Research Unit, Tasmanian Regional Laboratory, C.S.I.R.O., Hobart. Mr. Sykes has been engaged in food processing and quick-freezing investigations in the C.S.I.R.O., Food Preservation Laboratory at Homebush since 1945.

Mr. Eric Waring has accepted appointment as Lecturer in Agronomy at the Faculty of Rural Science, University of New England. Mr. Waring was previously an Agronomist with the Department of Agriculture.

Mr. N. R. Blanch is at present investigating methods of flour waste disposal for Wheat Industries (Aust.) Pty. Ltd., at their farm in the Tamworth District.

1958 Graduates' Appointments

Appointments accepted by the 1958 graduates include the following. Agronomist with D.S.I.R., Palmerston North, New Zealand—*Mr. J. Wilson.* To C.S.I.R.O., Canberra—*Miss Barbara Ballantyne.* To the N.S.W. Department of Agriculture — Biology Branch — *Messrs. R. J. Roughley, R. W. McLeod, J. A. Pearman, C. D. Blake*—Plant Industry Division—*T. O. B. King* (Leeton), *B. J. Bridge* (Yanco)—Animal Industry Division—*R. Beilharg.* Continuing their studies at Sydney University are *Mr. D. Smiles* (Soils Science), *Mr. D. Lindsay* (Animal Husbandry) and *R. Stephanson* (Soils Science).

Victoria

Mr. B. D. Robinson, Senior Botanist at the I.C.I. Merrindale Research Station has returned from England and Europe where he visited plant research institutions.

Mr. K. D. Woodyer, Secretary of the Agricultural Research Liaison Section, CSIRO, has transferred to Canberra to assist *Mr. A. Gurnett-Smith* in the survey of the southern tablelands of N.S.W. which is designed to provide a basis for future research and extension planning. This investigation is a joint venture conducted by CSIRO and the N.S.W. Department of Agriculture. Mr. Woodyer was Honorary Secretary of the Victorian Branch in 1957.

Mr. D. McKenna, Rural Liaison Officer of the Commonwealth Bank, is in Malaya to assist the government in central banking legislation.

Professor J. K. Turner, Professor of Botany in the University of Melbourne is at present in England investigating syllabi and methods of teaching science in schools and universities. He will also study laboratories and equipment where plant research is being conducted. Since his departure, Professor Turner has already visited South Africa and Italy and will return via the United States in about six months' time.

Mr. F. E. King has returned to his position as Managing Director of the Shell Chemicals Distributing Co. in Johannesburg, South Africa. Mr. King has been in Melbourne for a time as Acting Managing Director of Shell Chemicals (Aust.) Pty. Ltd. during the absence overseas of Mr. T. W. Henderson.

Dr. L. M. Birt who has been working at the Department of Biochemistry in the University of Melbourne for the past four years has arrived in England to continue research at the University of Cambridge.

Emeritus Professor Sir Samuel Wadham left in February to visit English universities. Sir Samuel will be away at least six months.

Mr. G. W. Douglas, Co-ordinator of Rabbit Control, has returned from New Zealand where, as a member of a group of parliamentarians and farming industry representatives, he studied the methods and organisation employed by the Rabbit Destruction Council. Mr. Douglas and his two graduate assistants, *Mr. B. R. Woodfield* and *Mr. F. Tighe,* have now moved to their new office in the Institute building in East Melbourne.

Mr. F. L. French, Agricultural Research Officer in the Victorian Department of Agriculture spent a short time in Queensland in April when he saw the tobacco sales at Mareeba and visited the Tobacco Research Institute. He then journeyed to Parada to the Department of Agriculture and Stock's Tobacco Experiment Station before returning to Melbourne.

Mr. I. D. Wardrop has been awarded a General Motors Holdens post-graduate research fellowship. Valued at £1,200, the fellowship will allow Mr. Wardrop to continue his research at the University of Melbourne on general scientific problems underlying meat production.

Mr. R. S. Carne, who is doing research on coffee and tea and general advisory work from Aiyura in New Guinea spent some time in Melbourne recently.

Mr. Carne delivered an interesting address to the M.U.A.S. on "Advances in Agriculture in New Guinea."

Mr. S. Erlich has returned to the Biology Branch of the Victorian Department of Agriculture after spending three and a half years working on citrus and pasture pests at the Ministry of Agriculture's research station at Rehovot, Israel.

Sir Ian Clunies Ross, Chairman and *Mr. P. F. Butler,* Assistant Research Secretary of the Biological Science Division, of CSIRO, attended the 5th Indian Science Congress in Madras in January. They also inspected research laboratories in West Pakistan as guests of the Council for Scientific and Industrial Research.

Queensland

Mr. R. C. Colbran, Entomologist, Department of Agriculture and Stock, Brisbane, left on March 29th to travel to Berkeley, California, for advanced training in Nematology, under the direction of *Dr. Merlin W. Allen,* of the University of California. Mr. Colbran hopes to visit some other centres of research on plant parasitic nematodes in the U.S.A., and will be away from Australia for about a year.

Mr. R. Cullinane and *Mr. P. Kerridge* have been appointed Research Fellows in the Agriculture Faculty of the University, the former investigating soil fertility on the Darling Downs and the latter, fodder conservation in western Queensland.

Dr. B. R. Champ returned to Brisbane in April two and a half years of postgraduate study at the Imperial College Field Station in Berkshire. Dr. Champ's trip to England was financed by a Gowrie Scholarship. The results of his investigations into the effects of sub-lethal doses of insecticides on parasitism were presented as a thesis for which he received the degree of Doctor of Philosophy from London University.

Mr. G. C. Stubbs, technical adviser in Queensland for Wm. Cooper & Nephews (Aust.) Pty. Ltd., left in March for study tours of overseas countries where cattle disease problems are prevalent.

South Australia

Mr. J. K. Taylor, Chief of the Soils Division, C.S.I.R.O., has left on a 7 month tour of soil research centres of the U.S.A. and Europe. In the U.S.A. he will visit Universities in California, Arizona, Wisconsin and the U.S.D.A. headquarters at Washington D.C. In Canada, he will visit Ottawa and Montreal. He will complete his tour of the Continent by attending the International Soil Science Society Conference at Hamburg in August 1958.

Mr. J. Lee of C.S.I.R.O. has been elected Federal President Elect of the Australian Society of Animal Production.

Mr. R. Sedgley has completed his scholarship in the Agronomy Department of the Waite Institute and has taken an appointment with the C.S.I.R.O. at Deniliquin.

R. M. Carraill was awarded the S.A. Branch Prize as the outstanding student in the Faculty of Agriculture for 1957.

Western Australia

Mr. R. H. Brown of Westralian Farmers' Co-operative Limited has been seconded to the position of personal assistant to the general manager of the firm. For some time Mr. Brown has been managing the agricultural chemicals section.

Mr. L. W. Pym, formerly a Research officer and *Mr. N. McNeil,* previously a Dairy Adviser, have both resigned from the Department of Agriculture to take up positions as senior extension officers in the Junior Farmers' Federation of W.A.

Mr. L. J. Gaffney, previously a Poultry Adviser in the Department of Agriculture has resigned to accept a position with a poultry farmer in New South Wales. Mr. Gaffney will be handling the entire poultry breeding programme for the several farms run by the one owner.

Mr. Roger Watt who completed his degree course last year has now joined the Department of Agriculture as a Research officer.

Mr. M. G. Hawson, previously in Malaya for several years has now accepted an appointment with I.C.I.A.N.Z. in Melbourne.

Mr. J. Shalders with the W.A. Education Department has been recently transferred from the Narrogin Agricultural School to the Harvey Agricultural School.

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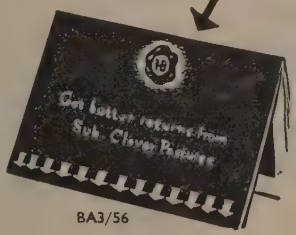

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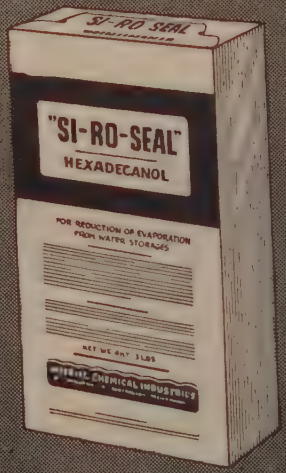

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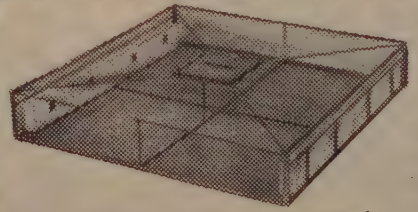

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Branch Notes

Australian Capital Territory

The Committee for this year is as follows:—

President—*Dr. R. D. Brock.*

Vice President—*Mr. W. M. Willoughby.*

Hon. Secretary—*Dr. D. L. Hayman.*

Hon. Treasurer—*Mr. R. C. L. White.*

Hon. Sub. Editor—*Mr. H. Lloyd Davies.*

Committee Members—*Mr. C. Johnstone, Dr. E. Phillis, Mr. W. Strutt.*

No nominations were received for the position of Hon. Assistant Secretary but the Committee intends to co-opt Mr. Graham Arnold who has indicated his willingness to accept the position.

The theme of this year's meetings is to be "Australian Agriculture of the Future". The opening address in the series was given by *Sir Ian Clunies-Ross,* C.M.G. on May 8.

It was entitled "Contribution of Science to Agriculture of the Future".

The series of meetings on the theme will include contributions from distinguished leaders in the fields of chemistry, physics, economics and rural sociology.
Federal President

A.C.T. Branch members will be most pleased to know that one of our former branch presidents, *Mr. R. Milton Moore,* has been elected Federal President of the Institute for 1957-8. Mr. Moore's continuous efforts on behalf of the Institute are already well known to this branch; we can only rejoice that he has been accorded this signal honour and wish him every success during his year of office.

New South Wales

The Annual General Meeting of the Branch was held on the evening of Friday, February 14. A buffet tea was arranged to precede the meeting and during tea members took the opportunity of discussing Institute affairs with the Executive Officer and other members. At the meeting the committee for 1958 was elected as follows:—

President: *Mr. J. D. McFarlane.*

Vice President: *Dr. R. L. Reid.*

Hon. Secretary: *Mr. E. H. Jacob.*

Hon Assistant Secretary: *Dr. B. G. Davey.*

Hon. Treasurer: *Mr. W. J. Greenhalgh.*

Members of Committee: *Messrs. D. L. Jackson, C. I. A. Beale, A. J. McIntyre, A. N. Johnston* and *Dr. M. C. Franklin.*

At a subsequent meeting *Mr. G. Alexander* was elected Hon. Sub-Editor for New South Wales.

A notice of motion to alter the Branch By-Laws to allow for the positions of Vice President and Immediate Past President in the Committee of Management, was defeated at the meeting. The discussion arising from this motion prolonged the general business of the meeting and, in view of the late hour, it was decided to defer the Presidential Address until a later date.

Branch members attended a meeting held at Sydney University on Tuesday, April 1, to hear *Dr. John Hammond* speak on recent advances in meat production. Dr. Hammond, who pioneered artificial stock breeding in the United Kingdom, is currently visiting Australia under the auspices of the Australian Meat Board.

The deferred Presidential address formed the main business of the meeting held in Science House on Friday, April 11. Dr. R. L. Reid spoke on some of the research being conducted by C.S.I.R.O., at Prospect, especially concerning the physiological basis of reproductive efficiency of the ewe. It is hoped that some of this lecture may be published in the journal at a later date.

The Branch together with the Sydney University Agricultural Graduates Association, again arranged a party for the Faculty of Agriculture graduates on the evening of graduation day, April 22. This function, which is becoming an annual event, is held to personally welcome the new graduates to the profession and the Institute.

Victoria

The Twenty Third Annual General Meeting of the Branch was held at the School of Agriculture, University of Melbourne on Friday, March 28.

The Meeting adopted the annual report and financial statement for 1957 and the Branch levy for 1958 was set at 10/6 per corporate member—the same as last year.

The following members were elected office bearers in the 1958 Committee:

President—*Mr. W. B. C. Mackie.*

Vice President—*Mr. R. E. Loder.*

Honorary Secretary—*Mr. W. R. Geary.*

Hon. Assistant Secretary—*Mr. G. W. Douglas.*

Hon. Treasurer—*Mr. L. C. Jones.*

Committee Members—*Mr. A. L. Tisdall; Mr. A. W. Stewart; Mr. R. S. Harper.*

Hon. Recorder—*Mr. B. Sellars.*

Hon. State Sub-editor—*Mr. J. P. Brien.*

Immediate Past President—*Mr. T. S. Bellair.*

Professor of Agriculture (Ex. officio)—*Professor H. C. Forster.*

Mr. T. S. Bellair's Presidential Address entitled "The Melbourne Milk Supply has both Quality and Efficiency" created a great deal of interest. A summary of his talk appears elsewhere in this issue.

Northern Victoria Sub-Branch

The Northern Victoria Sub-Branch held its first general meeting on March 28 at Wangaratta when *Mr. J. V. Mullaly,* Agricultural Research Officer of the Department of Agriculture, gave an illustrated lecture on his recent overseas trip. Mr. Mullaly spent nine months working with the cereal division of the Central Experiment Station, Ottawa and visiting research institutions and universities in the United States. The meeting was very well attended and received publicity in local newspapers.

Begun in November last year, the Northern Victoria Sub-Branch anticipates that it will hold three meetings a year in various local centres.

The Committee consists of:

Mr. N. Killeen—Chairman.

Mr. G. T. Levick; Mr. G. W. Hexter; Mr. J. Keatley—Vice Chairmen.

Mr. J. B. McPherson; Mr. I. H. Cameron—Joint Secretary Treasurers.

Queensland

The 28th General Meeting of the Institute was held in Brisbane on March 18. Following the meeting the Queensland Branch entertained visiting delegates to a dinner at the Manhattan Hotel, South Brisbane. *Dr. W. A. T. Summerville,* Federal President for 1957, delivered his Presidential Address entitled "Agricultural Research and the Farmer", after the dinner.

The 23rd Annual General Meeting of the Branch was held at the Department of Agriculture, University of Queensland on March 26. In the absence of the retiring President, *Professor L. J. H. Teakle* took the chair and conducted the election of office-bearers for 1958.

The officers elected were as follows:—

President—*Dr. D. O. Norris.*

Vice Presidents—*Mr. O. W. Sturgess* and *Mr. N. H. Shaw.*

Hon. Secretary—*Mr. A. G. A. Eyles.*

Hon. Asst. Secretary—*Mr. A. Hegarty.*

Hon. Treasurer—*Miss M. M. Kennedy.*

Hon. Sub-Editor: *Dr. E. F. Henzell.*

Committee Members—*Mr. B. L. Oxenham, Mr. W. J. Cartmill,* and *Mr. V. B. D. Skerman.*

Instead of the customary Presidential Address, which has been postponed during *Mr. N. H. Shaw's* absence overseas, the meeting heard a talk by *Mr. W. J. S. Sloan* of the Queensland Department of Agriculture and Stock. The speaker had recently returned after six months tour of the United States on a Rockefeller Foundation Fellowship, and in his address he described some aspects of agricultural research and extension in the U.S.A.

South Australia

The following committee has been elected for 1958:—

President: *Dr. G. M. E. Mayo.*
President Elect: *Mr. P. C. Angove.*
Secretary: *Mr. K. W. Shepherd.*
Assistant Secretary: *Mr. R. J. French.*
Treasurer: *Mr. M. B. Spurling.*
Committeemen: *Messrs. K. Barley, G. Edwards, Dr. E. Greacen.*
Auditors: *Mr. J. Harris, Dr. A. Rovira.*

Western Australia

Farmers and Scientists Joint Conference

This Conference organised jointly by the W.A. Branch of the A.I.A.S. and the Farmers' Union of W.A. was held on February 11, and 12, in Winthrop Hall at the University of W.A. The highlights of the function were:—

Official opening by His Excellency, the Governor, Sir Charles Gairdner.
A membership of about 610. Many other applications could not be accepted.
50 A.I.A.S. members attended.
Representatives from industry, stock firms and banks accounted for a further 60.
Overwhelming support for the suggestion that a somewhat similar Conference be held next year.
An enjoyable social evening at the Embassy Ballroom when members were the guests of Elder, Smith & Co.

Good organisation and arrangements beforehand resulted in smooth running of the actual conference. At this stage the Joint Organising Committee is still coping with the aftermath of the Conference, including the numerous comments, suggestions and constructive criticisms already received from many members.

The papers presented and the associated discussion have been recorded and will be printed as a book of Conference Proceedings. This will be distributed to those enrolled as members and will also be available at a small charge to persons who were unable to attend.

Branch Meeting—At the meeting held on March 21, *Professor E. J. Underwood* who has recently returned from a six-months visit to America, gave a talk in which he outlined his impressions of American agriculture and agricultural research. He also discussed the method of graduate training and research and also the ways in which the Universities, the U.S. Department of Agriculture and the commercial companies all play a part in agricultural research.

Tasmania

The 22nd Annual General meeting was held on the 17th February. The officers elected were as follows:—

President—*D. Berry.*
Vice President—*K. D. Nicholls.*
Secretary—*K. M. Stackhouse.*
Assistant Secretary—*N. M. Hudson.*
Treasurer—*K. W. N. Dillon* (Since resigned. *P. J. Sampson* appointed).
Journal Sub. Ed.—*J. R. Ward.*
Publicity Officer—*B. D. Frappell.*
Committeemen—*P. J. Fountain* and *I. D. Geard.*

The presidential address was postponed until 9th April when *Mr. Geard* spoke on "The Role of Therapy in the Control of Plant Diseases".
Mr. Ken Dillon has been transferred to A.C.T. where he has taken up appointment as S.R.O. Plant Quarantine Division of the Commonwealth Health Department.

Letters

Supply or Demand?

Dear Sir,
I do not think that fellow members would deny that an important justification for the existence of the A.I.A.S. is constantly to improve the working conditions, salaries and status of agricultural scientists in Australia. But what seems to be not so widely appreciated is that these things are themselves the key to the attainment of other objectives which the A.I.A.S. was originally formed to achieve and for which it continues to exist. Unless working conditions, salaries and status for a great majority of our members become attractive the profession of Agricultural Science is likely to remain at its present low ebb.

This state of affairs is not uniform throughout the profession. For many years it has been obvious that salaries and status are low for the majority of our members who are employed by State Departments of Agriculture, rather than for the minority employed in the Universities, CSIRO and private industry. So far the A.I.A.S. has achieved nothing towards the alleviation of the unsatisfactory conditions that exist so conspicuously in all State Departments of Agriculture, and therefore for most of its members. In fact the effects of the recent recruiting campaign are likely to worsen the situation and remove or postpone further the need for Directors of Agriculture and senior officers to promote, of their own volition, the necessary action through either their respective State Governments or the Australian Agricultural Council. Moreover there are not any signs from the A.I.A.S. Council that improvements are likely to be made in the foreseeable future as a result of A.I.A.S. efforts.

For this state of affairs, there are, I submit, two major reasons. One has already been mentioned. It is that neither members nor office-bearers—collectively—clearly see that conditions, salaries and status are largely the key to other objectives of the A.I.A.S. and that little will be achieved so long as the majority of members remain in a state of depression. Consequently we do not work for improvements in these directions with energy, resourcefulness and determination. Instead, we tend to dissipate our energies on Medals, Fellowships, Codes of Ethics, Publicity, Recruitment, an Australian Conference and another Journal etc.

The second reason is that our office bearers are dominated by employers' outlook. At bottom, again collectively, they regard themselves as employers rather than as members of a professional group in which all are of equal standing except perhaps for the honours colleagues and society may have accorded to an individual for some achievement. It is because our Councils have been dominated by this employers' outlook that we started out on a recruitment campaign, and why we accepted Commonwealth help to establish a permanent executive on conditions that excluded "trade union activities". And that is why when a Council did decide to look into conditions of work etc. it resolved only to "prepare a report *reviewing* the employment opportunities . . . and any other factors . . .*assessing* policy on recruitment, training and employment . . .", and that is why never, at any time, has the A.I.A.S. thought in terms of *creating* employment opportunities. This last point is not strictly true. The A.I.A.S. is concerned to persuade a private firm here and there to edge in one more agricultural graduate.

On the one thing that would probably best promote our professional objectives the A.I.A.S. has never acted. This thing is to create more and more employment opportunities for agricultural graduates. Create the demand and let the supply look after itself. Parents and students know what to do. The oil boom quickly filled geology schools and the new medical school in this University was soon filled to capacity without any recruitment campaign by the University or B.M.A. Unbalance between professions if it occurs is a matter for Governments, not the A.I.A.S.

The State Departments of Agriculture are the depression spots in our profession and they are likely to remain so for as long as there are no alternative avenues for the services of the graduates they employ. The State Governments are not likely to pay more than they have to to their employees even when they are members of the A.I.A.S.

In my view, during the next five to ten years, employment opportunities could be created for an extra 500-1000 graduates over and above the odd hundred or so we think of when we restrict our vision to the requirements of governmental services and private firms. In fact, farmers are beginning to recognize this and can see the need for one agricultural graduate in the field per 50-100 farmers, instead of one per 1000-2000 as at present. The promotion of farm management clubs throughout Australia, manned by University graduates, could achieve one main purpose of the A.I.A.S.—namely a substantial improvement in the farmer-agricultural scientist ratio, and in the best possible manner this will automatically improve the unattractive conditions typical for so long in the agricultural profession.

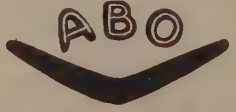
I earnestly request fellow members throughout Australia to critically assess the worth of the A.I.A.S. and to give thoughtful consideration to some bolder thinking and action such as that hinted at in this letter.

Yours etc.,

H. P. SCHAPPER

University of W.A.

CONTINUOUSLY AT WORK IN SCIENTIFIC AGRICULTURE



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Applications for the position set out hereunder will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, until and including 30 June, 1958.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience, and give particulars of war service (if any). Copies only of testimonials should be submitted with the application.

The appointee may be required to contribute to the Government Superannuation Fund.

Agricultural College Department.

LECTURER (OR SENIOR LECTURER) IN CHEMISTRY

Salary: Will be within the Graduate's range (£1,033/1,378) or that of Chemist (£1,488/1,653) or of Senior Lecturer (£1,708/1,873) depending on qualifications.

Duties: Teach chemistry to students in the courses leading to the diplomas in Agriculture, Oenology (Wine-making) and Dairying, and carry out such investigational work in agricultural and oenological chemistry as may be appropriate. Good facilities exist in a large new laboratory building. There will be no teaching in Oenology until 1960, by which time a second appointment will be made.

Qualifications: A University degree with organic or agricultural chemistry as major subjects.

Housing, etc.: A house is available for a married man at a rental of approximately £2/0/0 per week. For a single man full board is available at a charge at present £2/14/0 per week.

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AGRICULTURAL OFFICER GRADE I
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(a) £1,333-1,693 p.a. (graduates).
(b) £1,153-1,693 p.a. (diplomates).
(See also under "Salary.")

Qualifications:

(a) Degree in Agricultural Science; or
(b) Diploma approved Agricultural College, plus suitable experience preferably in tropics.

Duties:

General extension duties; maintain district agricultural stations; supervise special projects.

AGRONOMIST GRADE I

£1,333-1,693 p.a.
(See also under "Salary.")

Qualifications:

Degree in Agricultural Science, preferably with particular interest in Agronomy.

Duties:

Experimental work in Agronomy.

SOILS SURVEY OFFICER GRADE I

£1,333-1,693 p.a.
(See also under "Salary.")

Qualifications:

Degree in Agricultural Science, preferably with particular interest in Soils Science.

Duties:

Soil surveys; prepare maps and correlate data.

PLANT PATHOLOGIST GRADE I
(Microbiologist)

£1,288-1,693 p.a.
(See also under "Salary.")

Qualifications:

University Degree, with specialisation in pathology, bacteriology and mycology.

Duties:

Mainly microbiological, including research with symbiotic bacteria and on microbiological compounds in cocoa fermentation and tropical crop spoilage.

General Information

Salary:

Rates quoted are actual for unmarried appointees and include allowances and adjustments. Married officers receive a further £125 p.a. Additional Territorial Allowance of £25 p.a. after 5 years' service and a further £25 after 7 years' service is also payable.
Appointees may be paid higher commencing salaries according to qualifications or experience, up to a maximum of £1,378 p.a. — unmarried rate.

Eligibility:

Adult male British subjects under 45 years of age.

Appointment:

Permanent, subject to satisfactory probationary period.

Location:

Appointees are required to serve anywhere in the Territory.

Accommodation:

Single quarters only available. Married accommodation not available under 18 months from date of appointment.

Separation Allowance:

Payable at discretion of Territory Administration; designed to compensate for added expense of married appointees obliged to maintain family outside Territory.

Leave:

Three months after 21 months in Territory. Additional three months' leave after six years' service and six months' furlough after 20 years' service.

Taxation:

Income derived by residents of Territory from sources within the Territory is not at present taxable under Commonwealth legislation.

Further Information:

An information handbook on the Public Service of the Territory is available from the Department of Territories, Canberra or Sydney, or from any Commonwealth Public Service Inspector, Commonwealth Employment Office or official country Post Office. Other enquiries to Department of Territories, Canberra ('phone U 0411, extension 29A).

Applications:

Submit on prescribed form available from offices mentioned under "Further Information":—
To the Secretary, Department of Territories, Canberra, by 19th July, 1958.

THE UNIVERSITY OF SYDNEY

Applications are invited for the following positions made available from Wheat Industry Research Funds. Applicants should be graduates in Agricultural Science or Science, or possess similar qualifications. Applicants will be appointed for three years in the first instance and the appointment may be continued. The commencing salary will be within the range specified and will depend on experience and qualifications. In addition a cost of living allowance (at present £11 per annum for men, £8 per annum for women) will be paid. Applications, with a statement of qualifications and giving the names of two referees, should be forwarded to reach the undersigned not later than 30th June, 1958.

Agricultural Microbiology

Research Fellow, who will be expected to develop a largely independent programme on production and use of legume inoculants, growth and survival of Rhizobia, variation and serology, etc. Salary Range £1,100-£1,800 per annum.

Research Assistant, for work on some aspect of the foregoing. Salary Range £800-£1,200 per annum.

Research Assistants (2 positions), for development of algal biological assay for soil fertility and for non-symbiotic fixation of nitrogen. Salary Range £800-£1,200 per annum.

Genetics

Research Fellows (2 positions) for work on genetics of rust in wheat. Commencing salary within the range £1,100-£1,500 per annum with progression to £1,800 per annum.

Research Assistant for breeding of disease resistant varieties of wheat. Headquarters: Castle Hill, 17 miles from Sydney. Salary Range £800-£1,200 per annum.

Agronomy

Research Assistant, for study of cultivation and rotation of soil fertility and fertilisers on yield and quality. Salary Range £800-£1,200 per annum.

Sydney,
May, 1958.

M. A. TELFER,
Registrar.

THE UNIVERSITY OF SYDNEY

SENIOR LECTURESHIP IN ANIMAL NUTRITION.

Applications are invited for the position of Senior Lecturer in Animal Nutrition. Post-graduate experience in a branch of animal nutrition, preferably in ruminant nutrition and intermediary metabolism, necessary. Appointee will be responsible, under the Professor of Animal Husbandry, for organising courses in nutrition for students of the Faculties of Veterinary Science and Agriculture and for integrating them with existing courses in Veterinary Physiology, Agricultural Chemistry and Bio-chemistry. Appointee will have access to University Farms and will be encouraged to develop his own research. Salary for a Senior Lecturer is within the range £2,200-80-£2,550 per annum, plus cost of living adjustment, and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house. Applications, giving the names of three referees, should be forwarded to reach the undersigned, from whom further information may be obtained, not later than 12th July, 1958.

Sydney,
May, 1958.

M. A. TELFER,
Registrar.

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